COMPUTER AIDED MANUFACTURING (CAM)

UNIT 1 (NC MACHINES)

Definition of Numerical Control (NC)

Numerical Control (NC) is a form of programmable automation in which the mechanical actions of a machine tool or other equipment are controlled by a program containing coded instructions (alphanumeric data)

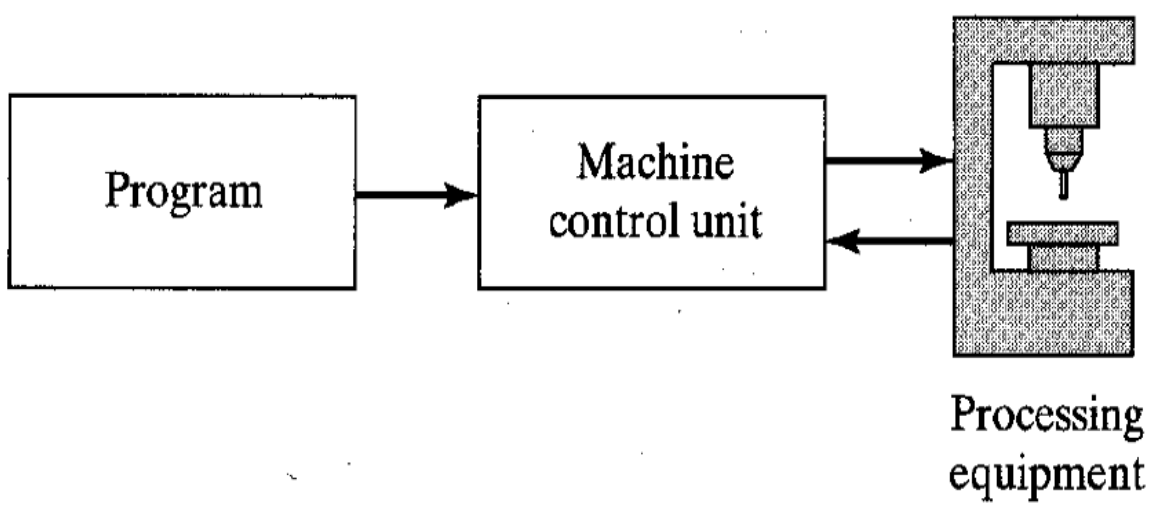
The collection of all instructions (or program of instruction) necessary to machine a part is called an NC program, CNC program, or a part program.

The person who prepares this program is called a part programmer.

Basic Components of NC System

An NC system consists of three basic components:

1.A program of instructions,
2.A machine control unit, and
3.Processing equipment.



Basic Components of NC System

1-Program of instruction

The program of instructions is the detailed step-by-step commands which refer to positions of a cutting tool relative to the worktable on which the workpart is fixed.

2-Machine Control Unit

It consists of a microcomputer and related control hardware that stores the program of instructions and executes it by converting each command into mechanical actions of the processing equipment, one command at a time.

3-Processing Equipment

It accomplishes the processing steps to transform the starting workpiece into a completed part. Its operation is directed by the control unit, which in turn is driven by instructions contained in the part program.

NC and CNC Technology

- The NC stands for the older and original Numerical Control technology.
- The CNC stands for the newer Computerized Numerical Control technology.
- Both systems perform the same task, namely manipulation of data for the purpose of machining a part.
- In both cases, the internal design of the control system contains the logical instructions that process the data.

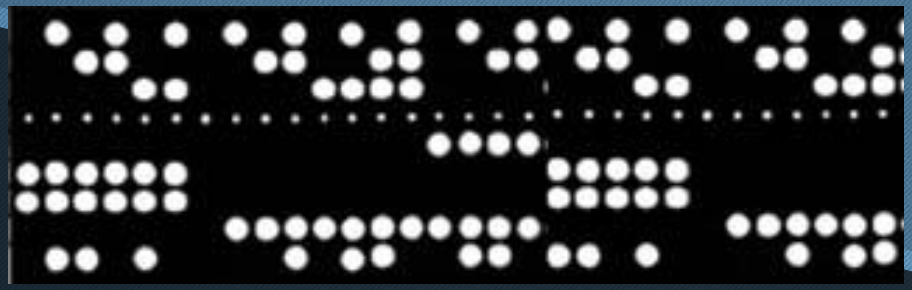
NC Technology

- The NC system uses a fixed logical functions, those that are built-in and permanently wired within the control unit.

- These functions can not be changed by the programmer or the machine tool operator.

- The system can interpret a part program, but it does not allow any changes to the program.

- NC system requires the use of punched tapes for input of the program instructions.



Types of NC systems

Open-loop Control system

Stepper motor is used, having a predefined amount of revolution.
Current pulses are send from MCU to individual motors.
Movement/rotation depends on number of pulses send.

Advantages:

1. Position is maintained just by keeping track of number of revolutions.
2. Can produce a movement of 1/1000th of an inch, for a single pulse.
3. Cheap and less complex.
4. Easy to maintain.

Drawback:

1. Assumption: Motor movement is precise, i.e. motor is moving the exact amount depending on the number of pulses.
2. No way to correct errors, because no feedback.
3. This control is not suitable for large machines requiring greater power
   because of limitation of stepper motor to generate high torque.

Closed-loop Control

- Direct current (DC) motors are used.
- Can generate high levels of torque.
- Can be reversed.
- Unlike stepper motors, it cannot achieve very precise movement.
- Separate positions sensors are required.
- Position information is fed back as a signal to the controller.
- Major advantage: because of feed back and servo motors
- Types of NC control systems
- reversible feature, errors can be corrected, by comparing with
- target position.
- Thus formed a closed loop.
- Higher accuracy than open loop systems because of feed back.

- Applications:

1. Larger NC machines because of higher loads.
2. For greater accuracy, any kind of load.

- Expensive and complex.

Advantages and Disadvantages of NC

The advantages generally attributed to NC, with emphasis on machine tool applications, are the following:

1. Non-productive time is reduced (fewer setups, less setup time, reduced work piece handling time, and automatic tool changes).
2. Greater accuracy and repeatability.
3. More-complex part geometries are possible.
4. Simplified tooling and work holding.
5. Operator skill-level requirements are reduced.
6. Inspection requirements are reduced.

The disadvantages of NC include the following:

1. Higher investment cost.
2. Higher maintenance effort.
3. Part programming.

APPLICATION OF NC MACHINE

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

• *NC boring mill,* horizontal and 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.

• *NC drill press.* These machines use point-to-point control of the work head (spindle containing the drill bit) and two axis *(x-y)* control of the worktable. Some NC drill presses have turrets containing six or eight drill bits. The turret position is programmed under NC control. thus 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.

• *NC milling machine.* Milling machines require continuous path control to perform straight cut or contouring operations. Figure 6.11 illustrates the features of a four axis milling machine.

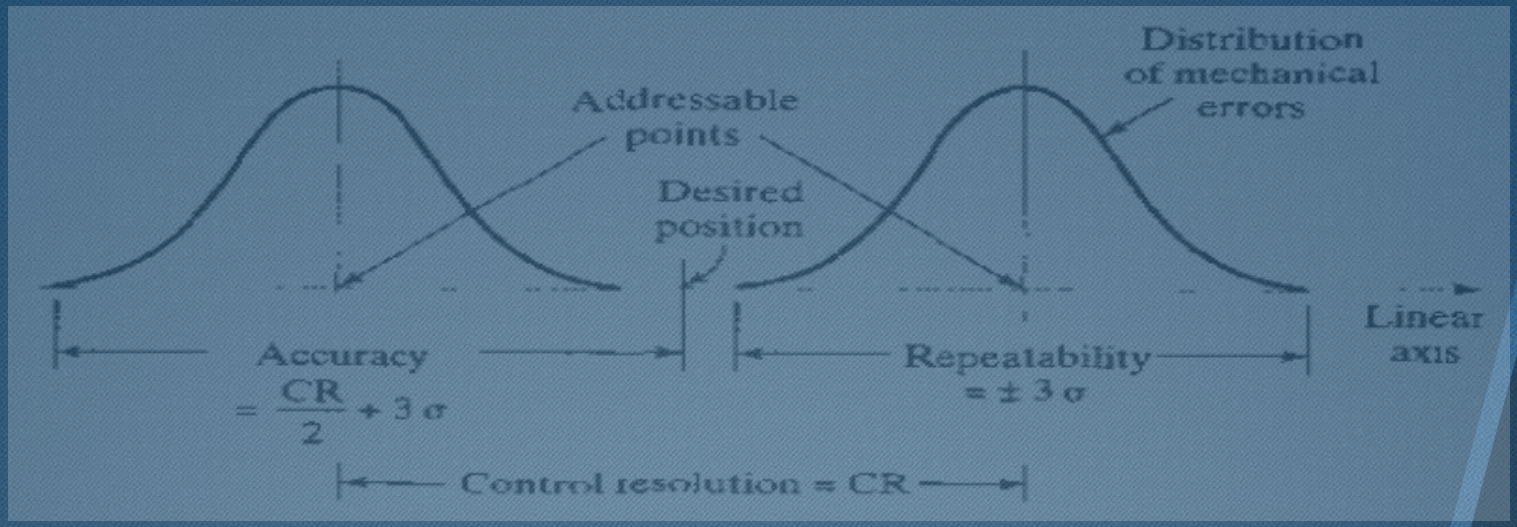
METHODS FOR IMPROVING ACCURACY

For accurate machining or other processing performed by an NC system, the positioning system must possess a high degree of precision. Three measures of precision can be defined for an NC positioning system: (I) control resolution. (2) accuracy, and (3) repeatability. These terms are most readily explained by considering a single axis of the positioning system. Control resolution refers to the control system's ability to divide the total range of the axis movement into closely spaced points that can be distinguished by the Men *Control resolution* is defined as the distance separating two adjacent addressable points in the axis movement. *Addressable points* are locations along the axis to which the worktable can be specifically directed to go. It is desirable for control resolution to be as small as possible. This depends on limitations imposed by:

(1) the electromechanical components of the positioning system and/or

(2) the number of bits used by the controller to define the axis coordinate location.

A number of electromechanical factors affect control resolution, including: lead screw pitch, gear ratio in the drive system, and the step angle in a stepping motor for an open-loop system or the angle between slots in an encoder disk for a closed-loop system. For an open loop positioning system driven by a stepper motor, these factors can be combined into an expression that defines control resolution as follows:



$$CR_1 = \frac{p}{n_s r_g}$$

where CRj = control resolution of the electromechanical components (rnrn.in], *p* '= lead screw pitch (nun/rev, in/rev), *n.* = number of steps per revolution, and *'g* = gear ratio between the motor shaft and the lead screw as defined in equation. A similar expression can be developed for a closed-loop positioning system, except that the gear reduction between the lead screw and the encoder shaft must be included:

$$CR_1 = \frac{p}{n_s r_g r_{ge}}$$

The second factor that limits control resolution is the number of bits used by the *MeV* 10 specify the axis coordinate value. For example, this limitation may be imposed by the bit storage capacity of the controller. If *B '"* the number of bits in the storage register for the axis, then the number of control points into which the axis range can be divided = 2B.Assuming that the control points are separated equally within the range, then

$$CR_2 = \frac{L}{2^B - 1}$$

where CR2 '= control resolution of the computer control system [mm, in), and *L* = axis
range (rom, in). The control resolution of the positioning system is the maximum of the two
values; that is :

$$CR = \text{Max}\{CR_1, CR_2\}$$

A desirable criterion is for CR2 : CR1, meaning that the electromechanical system is the limiting factor that determines control resolution. The bit storage capacity of a modem computer controller is sufficient to satisfy this criterion except in unusual situations. Resolutions of 0.0025 mm (0,0001 in) are within the current state of NC technology.