1. What is NC?

- Numerical control (NC) refer to control of a machine or a process using symbolic codes consisting of characters and numerals.

- The word CNC came into existence in 7th when microprocessors and microcomputers replaced integrated circuit IC based controls used for NC machines.

- The concept of NC was proposed in the late 1940s by John Parsons who recommended a method of automatic machine control that would guide a milling cutter to produce a curvilinear motion in order to generate smooth profiles on the work-pieces.
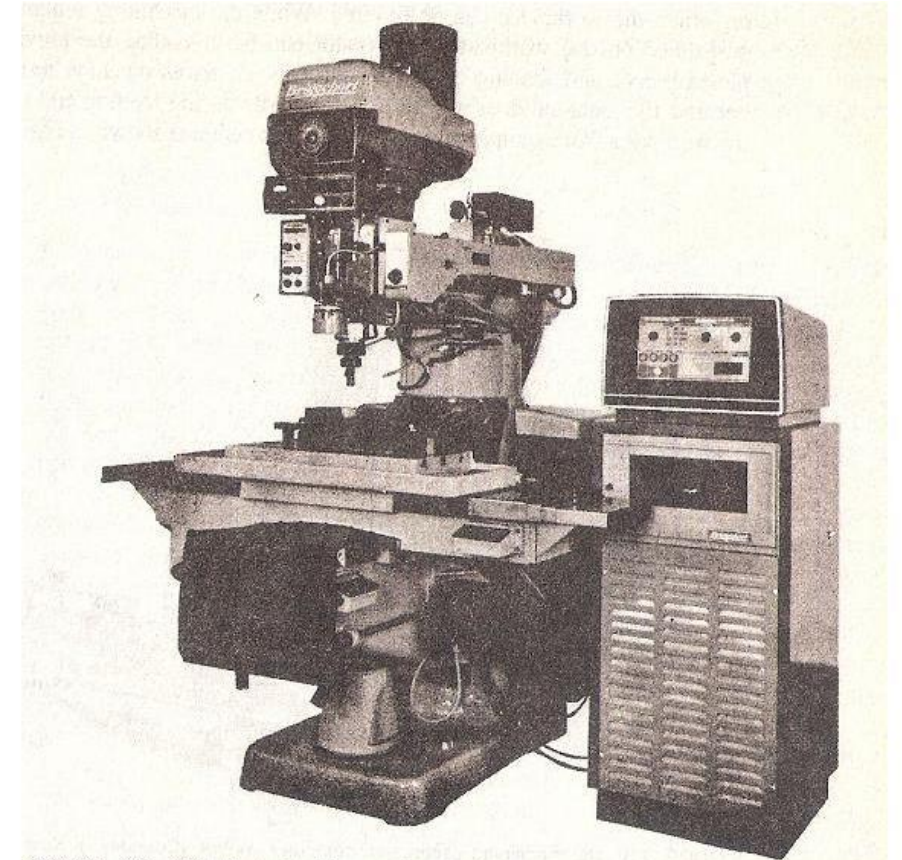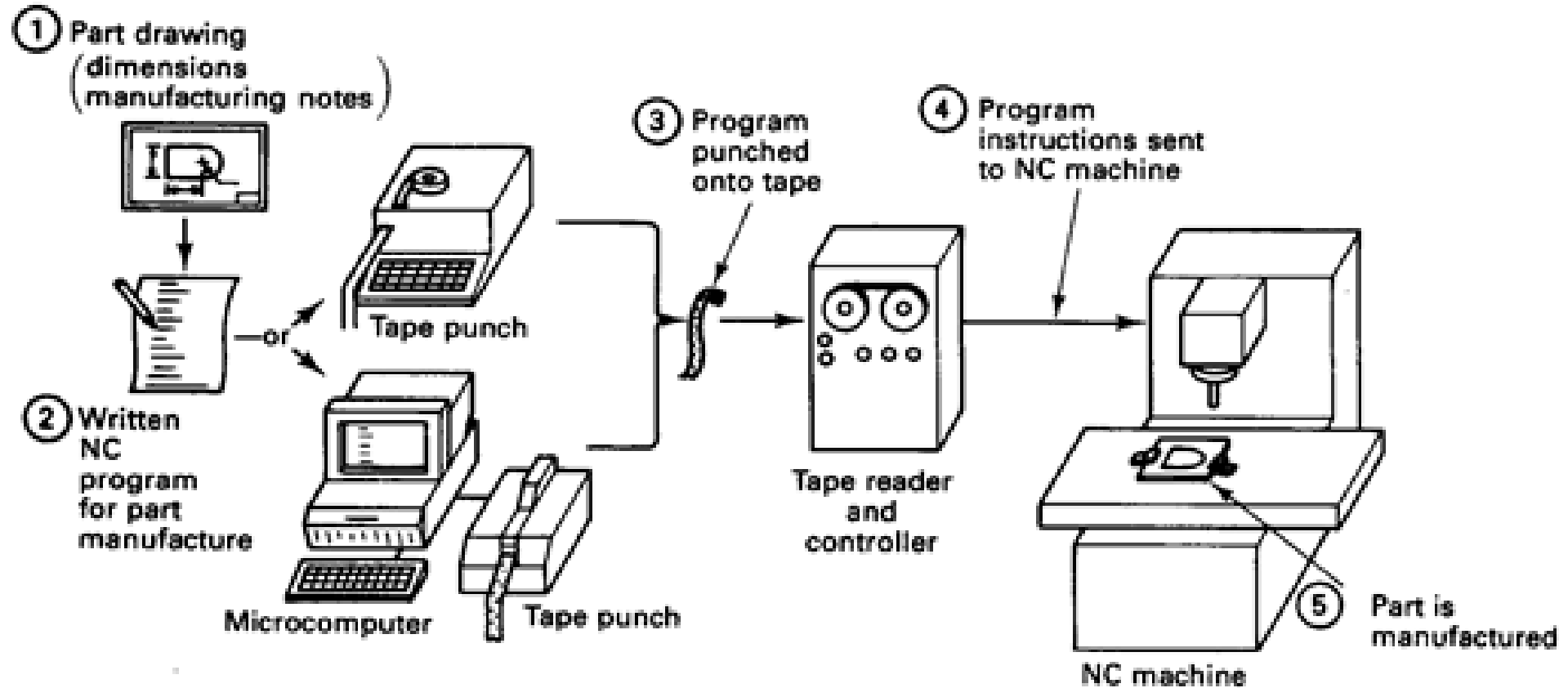

FIGURE 7.2 NC system showing machine tool and controller. (Courtesy of Bridgeport Machines Division of Textron Inc.)

2. Components of traditional NC systems

① Part drawing (dimensions, manufacturing notes)

② Written NC program for part manufacture

Tape punch

Microcomputer — Tape punch

③ Program punched onto tape

Tape reader and controller

④ Program instructions sent to NC machine

⑤ Part is manufactured

NC machine

3. Advantages of NC systems over manual methods of production

- Better control of the tool motion under optimum cutting conditions.

- Improved part quality and repeatability.

- Reduced tooling costs, tool wear, and job setup time.

- Reduced time to manufacture parts.

- Reduced scrap.

- Better production planning and placement of machining operations in the hand of engineering.
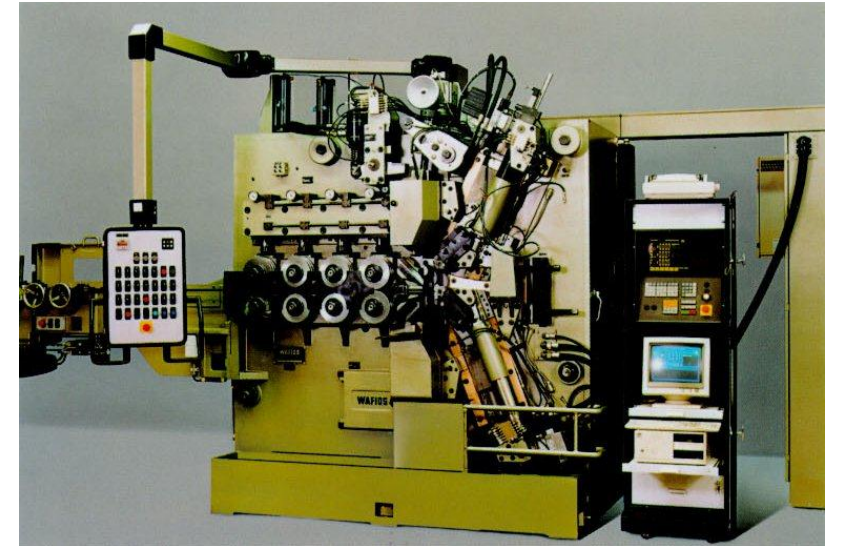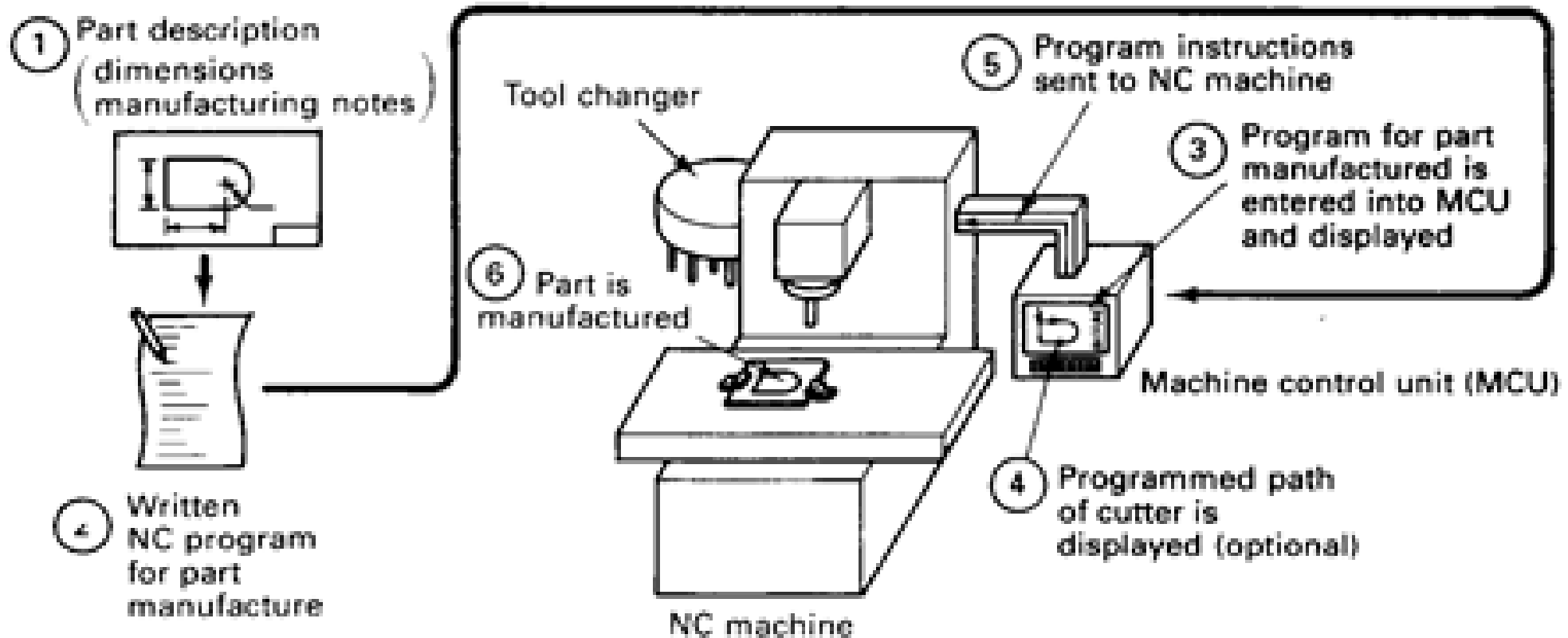
4. Computer Numerical Control (CNC)

- Computer numerical control (CNC) is the numerical control system in which a dedicated computer is built into the control to perform basic and advanced NC functions.

- CNC controls are also referred to as soft-wired NC systems because most of their control functions are implemented by the control software programs.

- CNC is a computer assisted process to control general purpose machines from instructions generated by a processor and stored in a memory system.


CNC Milling Machine.

5. Components of modern CNC systems

① Part description (dimensions, manufacturing notes)

② Written NC program for part manufacture

Tool changer

⑥ Part is manufactured

⑤ Program instructions sent to NC machine

③ Program for part manufactured is entered into MCU and displayed

④ Programmed path of cutter is displayed (optional)

Machine control unit (MCU)

NC machine

6. Advantages of CNC systems

- CNC machines can be used continuously and only need to be switched off for occasional maintenance.

- These machines require less skilled people to operate unlike manual lathes/milling machines etc.

- CNC machines can be updated by improving the software used to drive the machines.

- Training for the use of CNC machines can be done through the use of "virtual software".
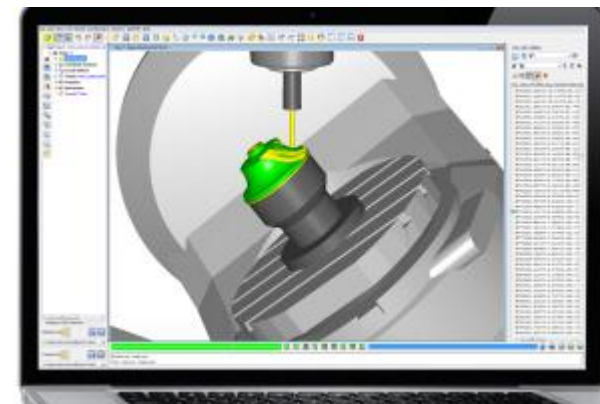
6. Advantages of CNC systems

- The manufacturing process can be simulated virtually and no need to make a prototype or a model. This saves time and money.

- Once programmed, these machines can be left and do not require any human intervention, except for work loading and unloading.

- These machines can manufacture several components to the required accuracy without any fatigue as in the case of manually operated machines.

- Savings in time that could be achieved with the CNC machines are quite significant.

8. Disadvantages of CNC systems

- CNC machines are generally more expensive than manually operated machines.

- The CNC machine operator only needs basic training and skills, enough to supervise several machines.

- Increase in electrical maintenance, high initial investment and high per hour operating costs than the traditional systems.

- Fewer workers are required to operate CNC machines compared to manually operated machines. Investment in CNC machines can lead to unemployment.

9. Direct Numerical Control (DNC)

- In a **Direct Numerical Control system** (DNC), a mainframe computer is used to coordinate the simultaneous operations of a number NC machines.

- The main tasks performed by the computer are to program and edit part programs as well as download part programs to NC machines.

- Machine tool controllers have limited memory and a part program may contain few thousands of blocks. So the program is stored in a separate computer and sent directly to the machine, one block at a time.


DNC systems
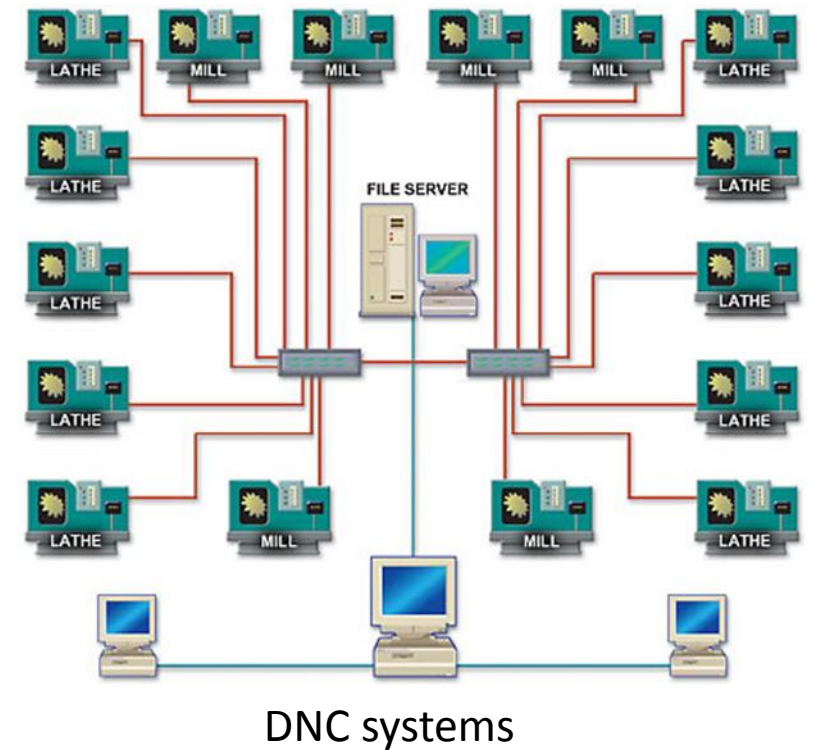
10. Distributed Numerical Control (DNC)

- Distributed NC is known by the same acronym as Direct Numerical Control (DNC).

- After the introduction of CNC, the machine tools have had the capability of storing large amount of information. Therefore, there have been no need to have drip feed information system, like, Direct Numerical Control. Instead, Distributed Numerical Control is introduced. In such a system, a host computer communicate with many CNC machine tools via networks and download or upload programs.

- With Distributed Numerical Control systems, it is possible to monitor the activities in individual CNC machine tools on host computer. Therefore, better shop floor control can be achieved.

DNC systems
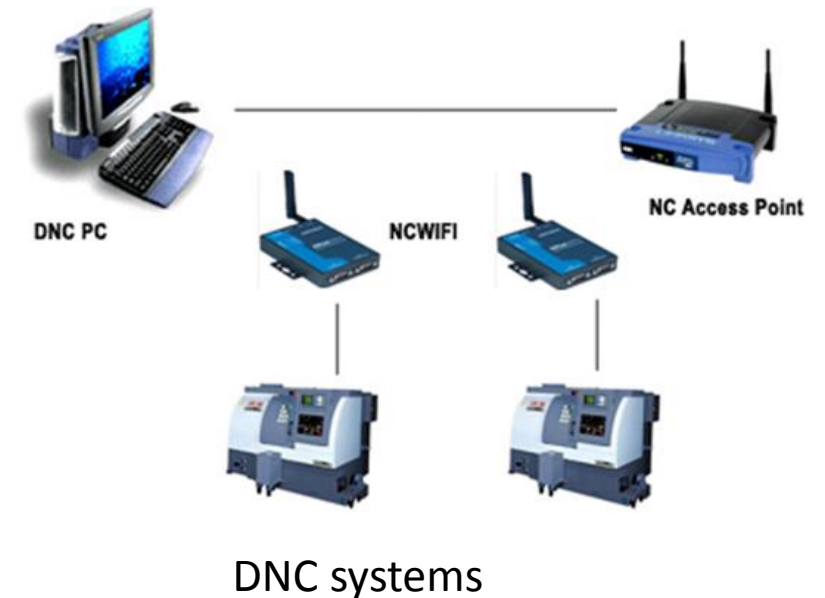
11. Application of CNC Machine Tools

- CNC was initially applied to metal working machinery: Mills, Drills, boring machines, punch presses etc and now expanded to robotics, grinders, welding machinery, EDM's, flame cutters and also for inspection equipment etc.
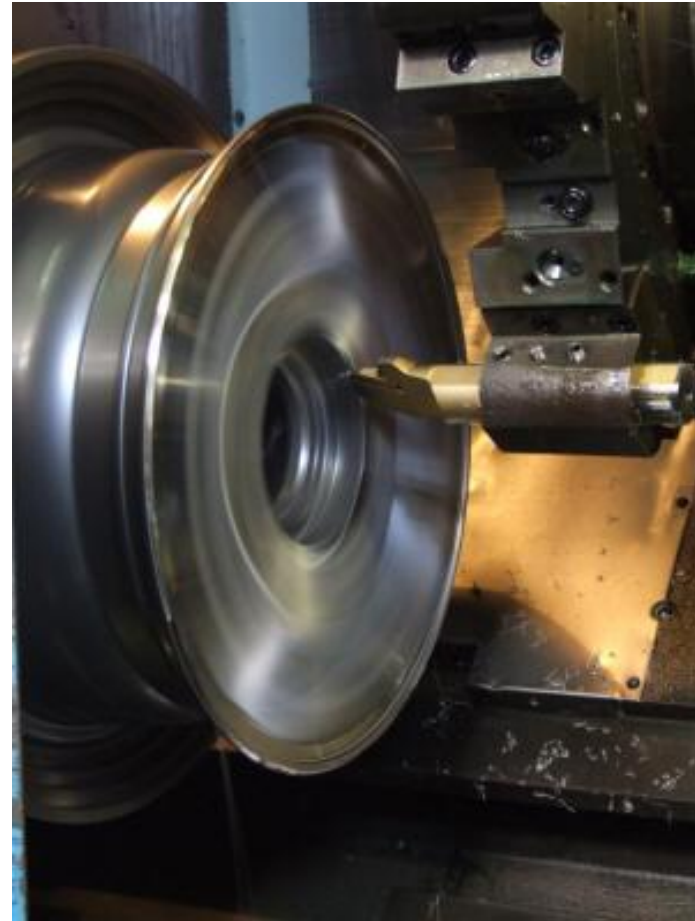
11. Application of CNC Machine Tools

- The machines controlled by CNC can be classified into the following categories:
  - CNC mills and machining centers,
  - CNC lathes and turning centers
  - CNC electrical discharge machining (EDM)
  - CNC grinding machines
  - CNC cutting machines (laser, plasma, electron, or flame)
  - CNC fabrication machines (sheet metal punch press, bending machine, or press brake)
  - CNC welding machines

11. Application of CNC Machine Tools

CNC Vertical Machining Center

11. Application of CNC Machine Tools

CNC Turning Machining Center

11. Application of CNC Machine Tools

CNC Laser Cutting Machine

11. Application of CNC Machine Tools

CNC EDM Machine

11. Application of CNC Machine Tools

CNC Hydraulic Plate Punching And Marking Machine

11. Application of CNC Machine Tools
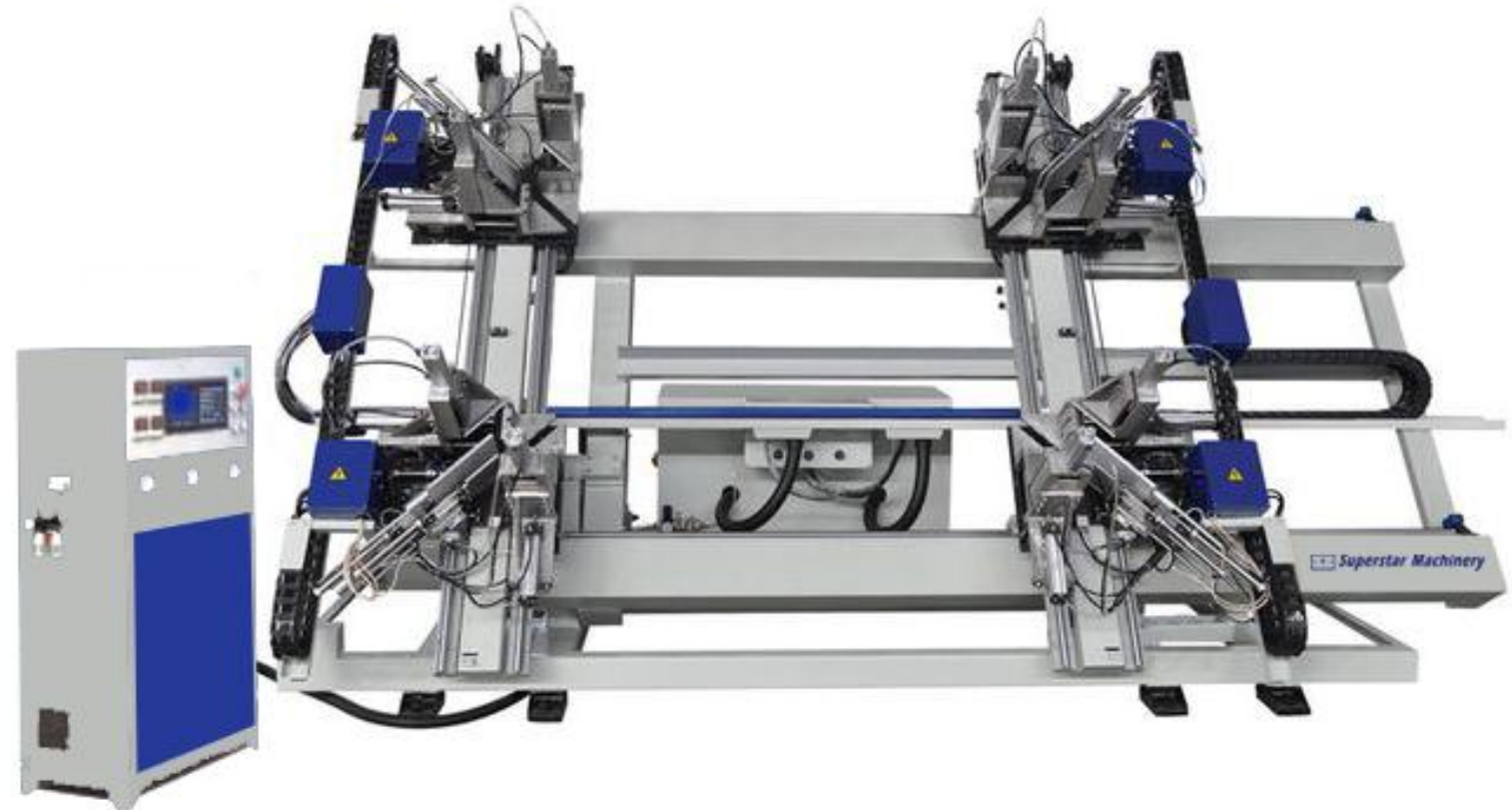
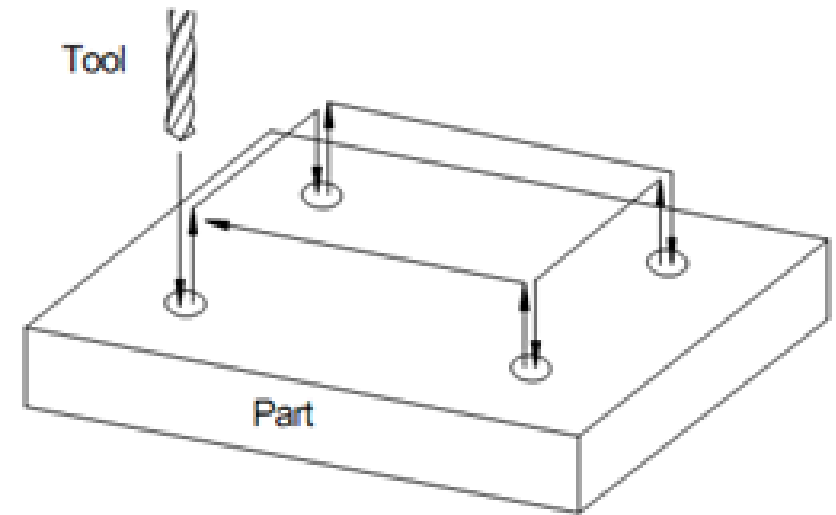CNC Four-point Welding Machine

12. Classification of CNC Machines

1. Classification based on the motion type.

2. Classification based on the control loops.

3. Classification based on the number of axes.

4. Classification based on the power supply.

12. Classification based on the motion type.

Point-to-Point Systems.

1. It is used in some CNC machines such as drilling, boring and tapping machines…etc.

2. The control equipment for use with them are known as point-to-point control equipment.

3. Feed rates need not to be programmed.

4. In theses machine tools, each axis is driven separately.

12. Classification based on the motion type.

Contouring Systems (Continuous Path Systems)

- It is used in CNC machine tools such as milling machines.

- These machines require simultaneous control of axes.

- Contouring machines can also be used as point-to-point machines, but it will be uneconomical to use them unless the work piece also requires having a contouring operation to be performed on it.
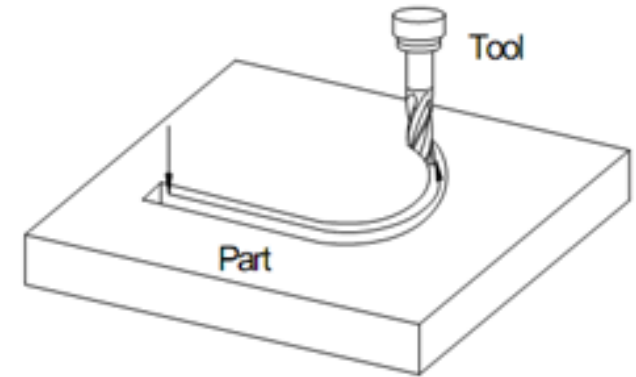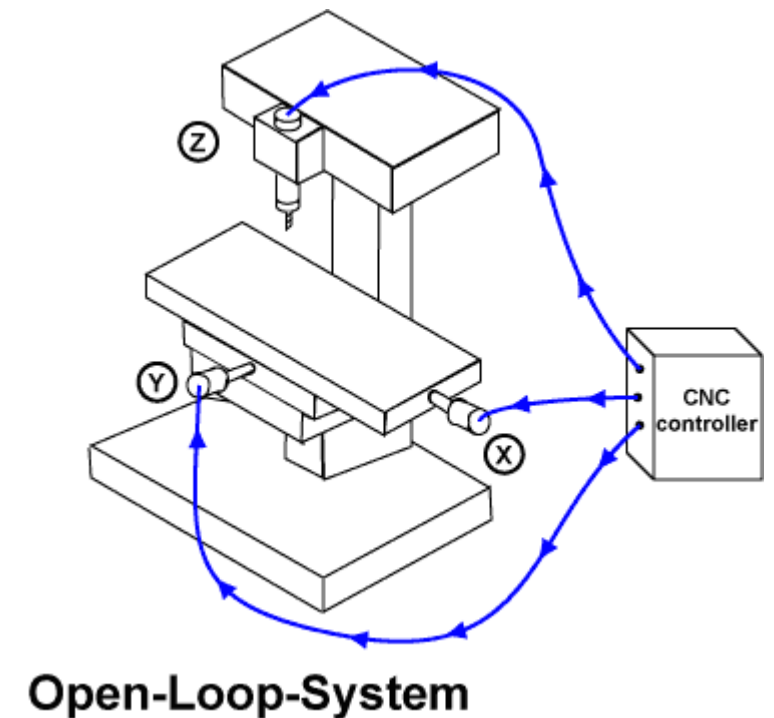
12. Classification based on the motion type.
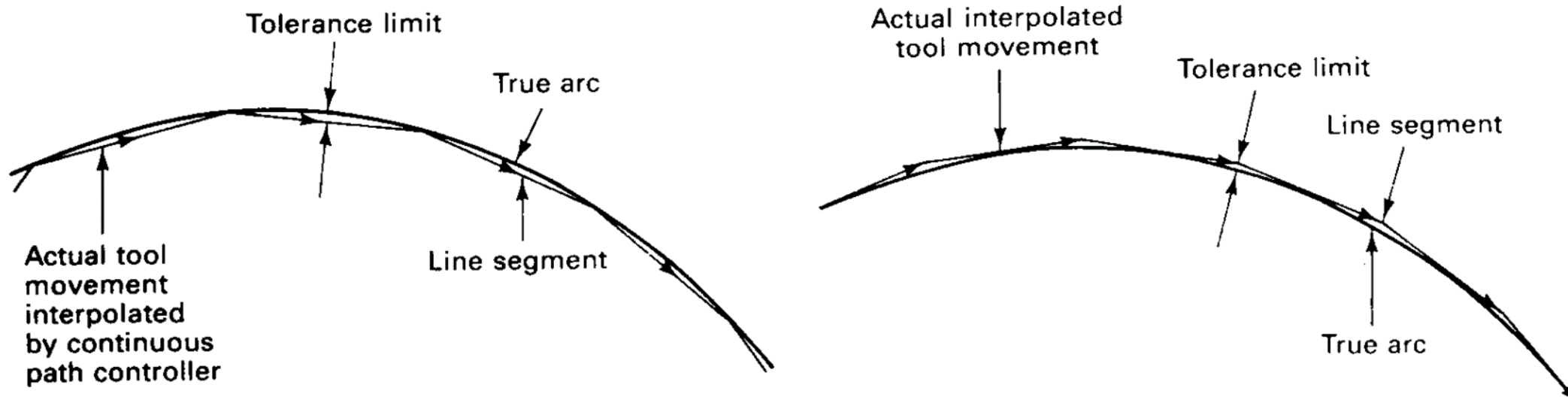
Interpolation used for continuous-path movement.

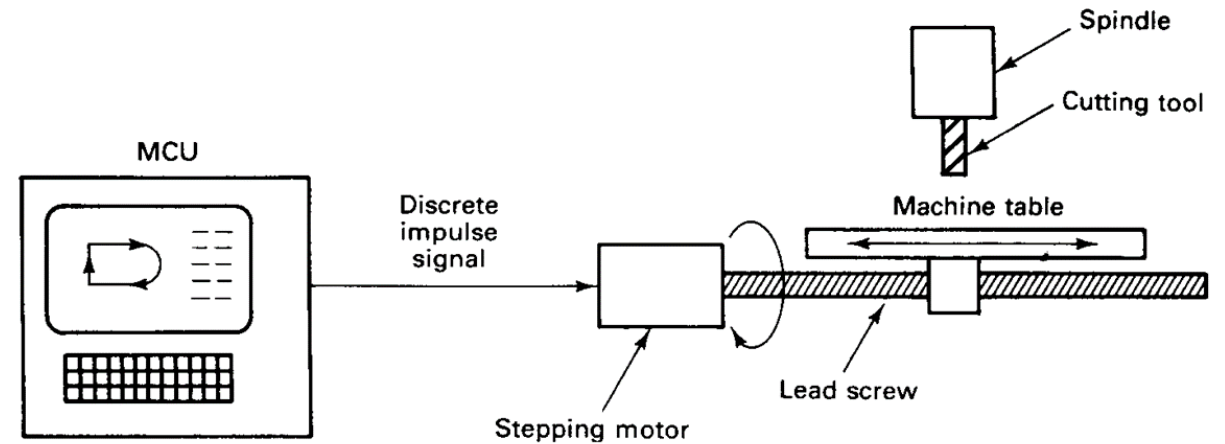# 13. Classification based on the control loops

Open Loop Systems

- Programmed instructions are fed into the controller through an input device.

- These instructions are then converted to electrical pulses (signals) by the controller and sent to the servo amplifier to energize the servo motors.

- The primary drawback of the open-loop system is that there is no feedback system to check whether the program position and velocity has been achieved.

Open-Loop-System

13. Classification based on the control loops

Open Loop Systems

- the open -loop system is generally used in point-to-point systems where the accuracy requirements are not critical.

- Very few continuous-path systems utilize open-loop control.

Configuration for an open loop system.

13. Classification based on the control loops
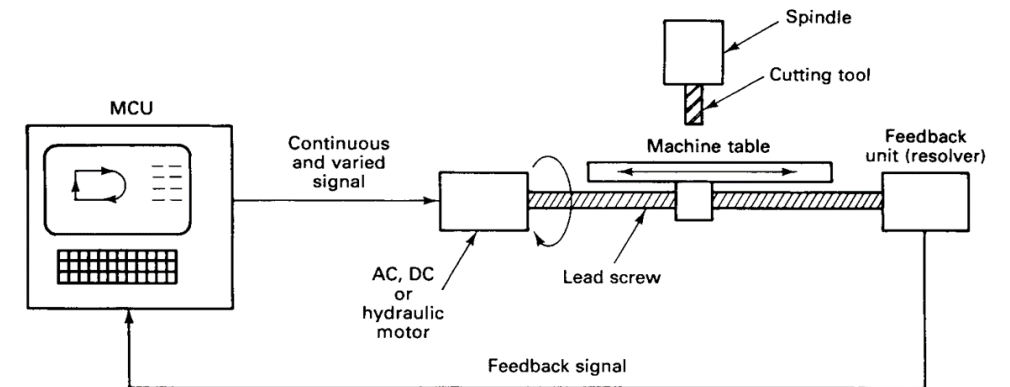
Closed Loop Systems

- The closed-loop system has a feedback subsystem to monitor the actual output and correct any discrepancy from the programmed input.

- These systems use position and velocity feed back.

- The feedback system could be either analog or digital.
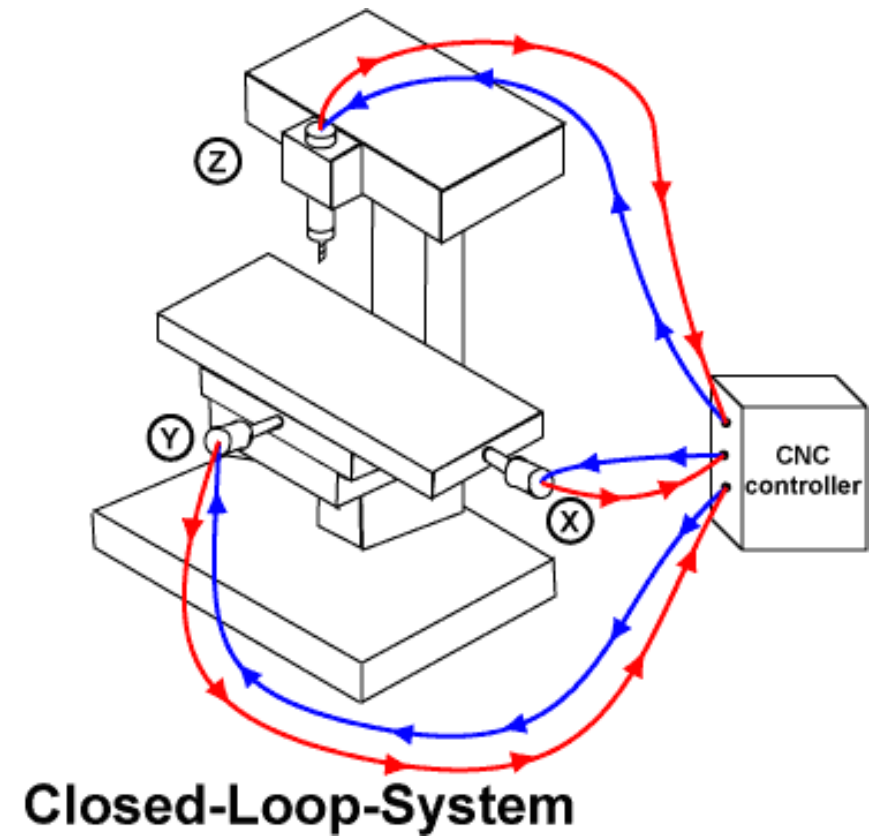
Closed-Loop-System

13. Classification based on the control loops

Closed Loop Systems

- The analog systems measure the variation of physical variables such as position and velocity in terms of voltage levels.

- Digital systems monitor output variations by means of electrical pulses.

- Closed-loop systems are very powerful and accurate because they are capable of monitoring operating conditions through feedback subsystems and automatically compensating for any variations in real-time.


Configuration of a closed loop system.

14. Classification based on the number of axes

2&3 axes CNC Machines

- CNC lathes will be coming under 2 axes machines. There will be two axes along which motion takes place.

- The saddle will be moving longitudinally on the bed (Z-axis) and the cross slide moves transversely on the saddle (along X-axis).

- In 3-axes machines, there will be one more axis, perpendicular to the above two axes.

- By the simultaneous control of all the 3 axes, complex surfaces can be machined.

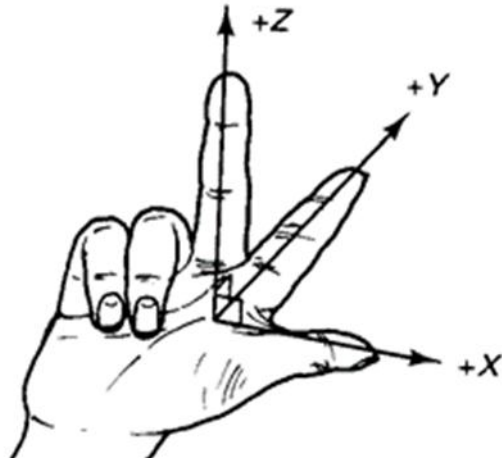# 14. Classification based on the number of axes
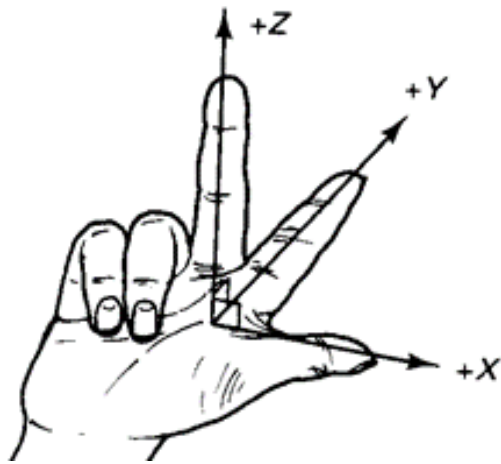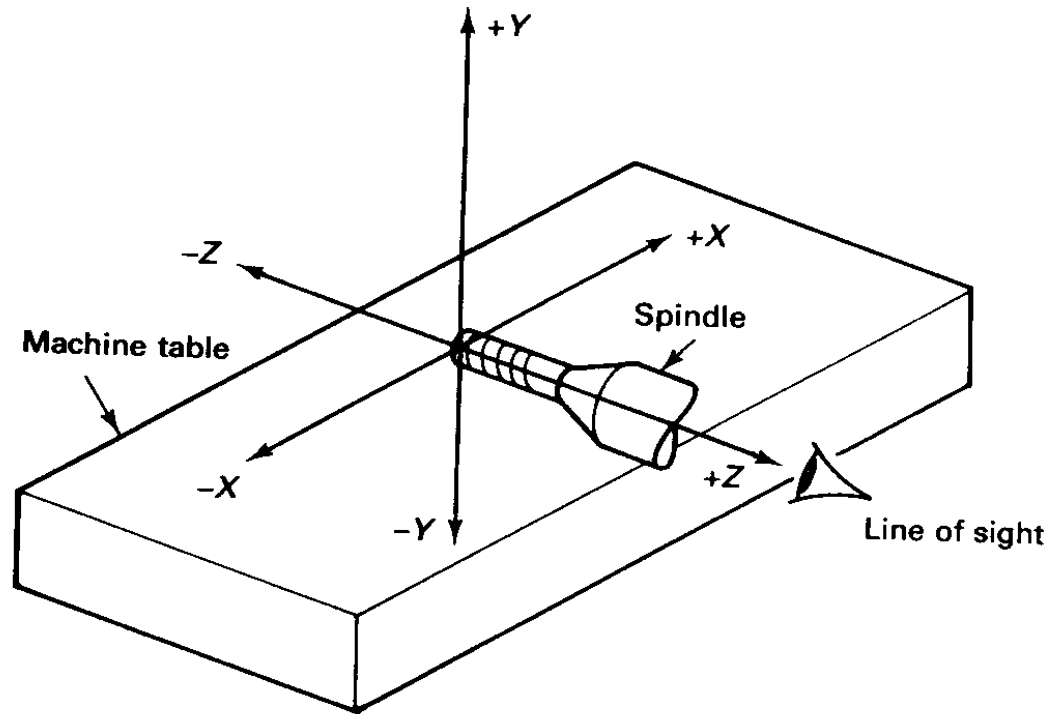

The right-hand rule for linear motion.
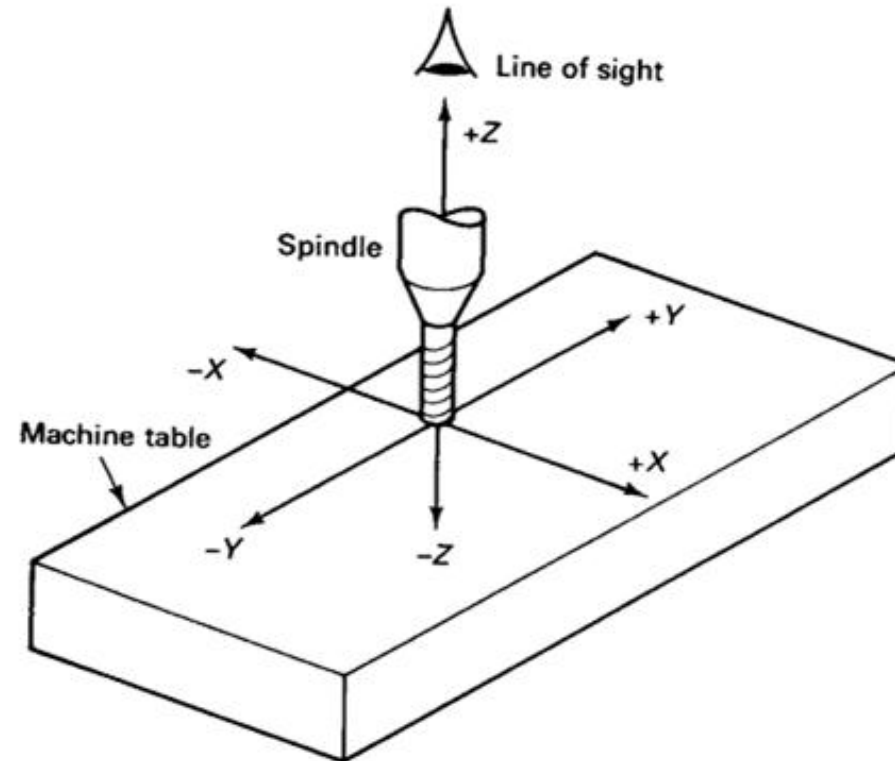
Machine axis for a three-axis vertical CNC machine (machine axis defined as spindle movement).

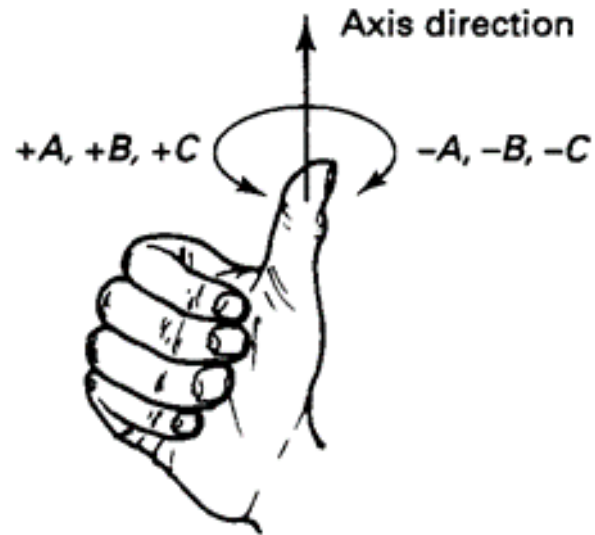# 14. Classification based on the number of axes

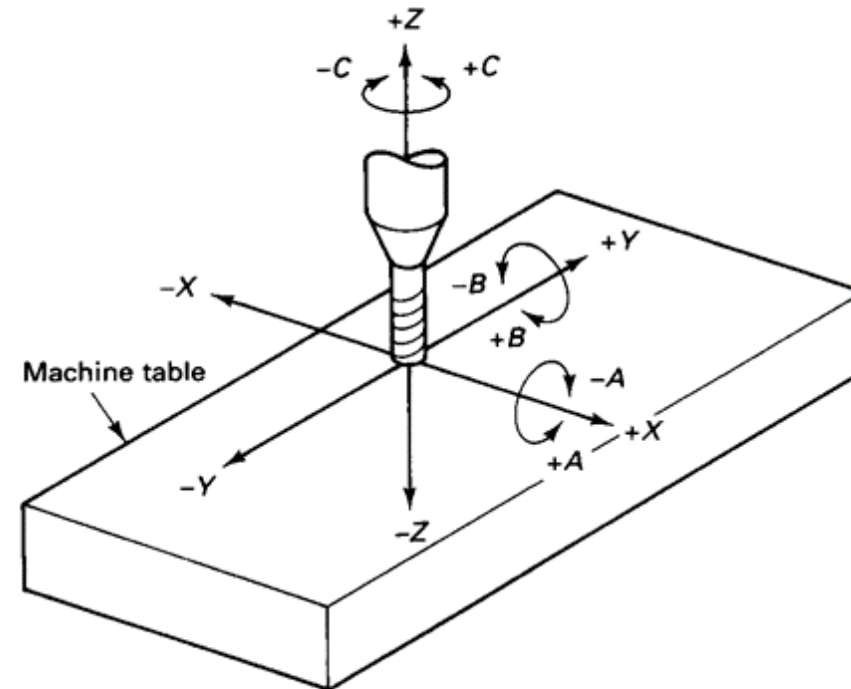
The right-hand rule for linear motion.

Machine axis for a three-axis horizontal CNC machine (machine axis defined as spindle movement).

14. Classification based on the number of axes

The right-hand rule for rotary motion.

Machine axes for six-axis vertical CNC machine (machine axis defined as spindle movement).

14. Classification based on the number of axes

Importance of higher axes machining:

• Reduced cycle time by machining complex components using a single setup.

• In addition to time savings, improved accuracy can also be achieved as positioning errors between setups are eliminated.

• Improved surface finish and tool life by tilting the tool to maintain optimum tool to part contact all the times.
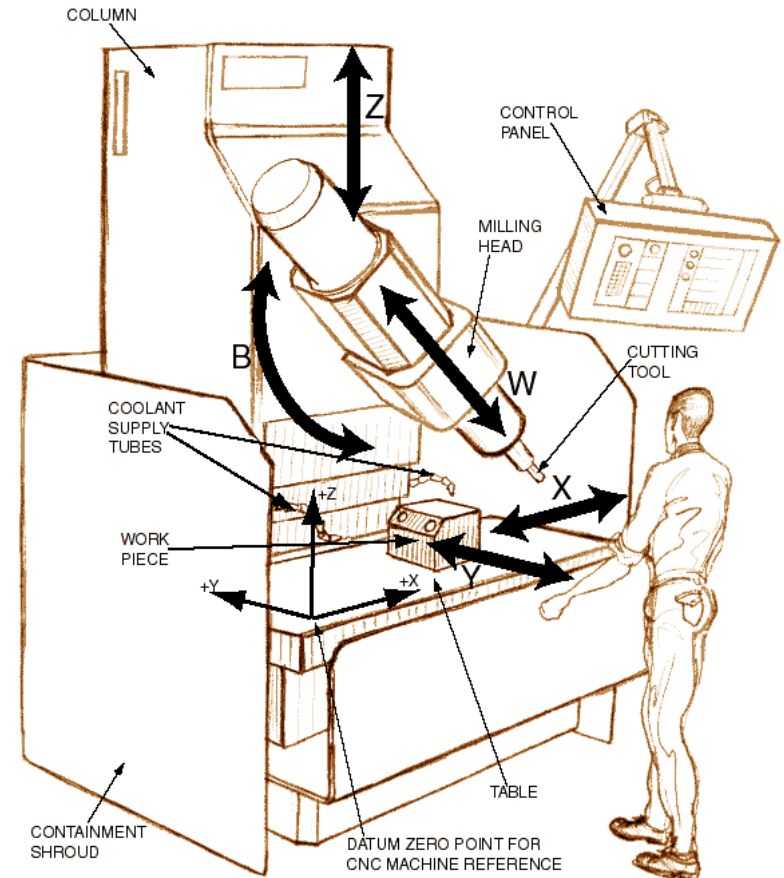
14. Classification based on the number of axes

Importance of higher axes machining:

- Improved access to under cuts and deep pockets. By tilting the tool, the tool can be made normal to the work surface and the errors may be reduced as the major component of cutting force will be along the tool axis.

- Higher axes machining has been widely used for machining sculptures surfaces in aerospace and automobile industry.

14. Classification based on the power supply

- Mechanical power unit refers to a device which transforms some form of energy to mechanical power which may be used for driving slides, saddles or gantries forming a part of machine tool.

- The input power may be of **electrical**, **hydraulic** or **pneumatic**.

AC Servo Motor for CNC Machine Tool

Thank You