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Fundamentals of CNC

Components of CNC Machine (UNIT -5)

Components of a CNC System

Any CNC machine tool essentially consists of the following parts:

(1.1) Part program:

A part program is a series of coded instructions required to produce a part. It controls the movement of the machine tool and on/off control of auxiliary functions such as spindle rotation and coolant. The coded instructions are composed of letters, numbers and symbols.

(1.2) Program input device:

The program input device is the means for part program to be entered into the CNC control. Three commonly used program input devices are punch tape reader, magnetic tape reader, and computer.

(1.3) Machine Control Unit

The machine control unit (MCU) is the heart of a CNC system. It is used to perform the following functions:

To read the coded instructions.

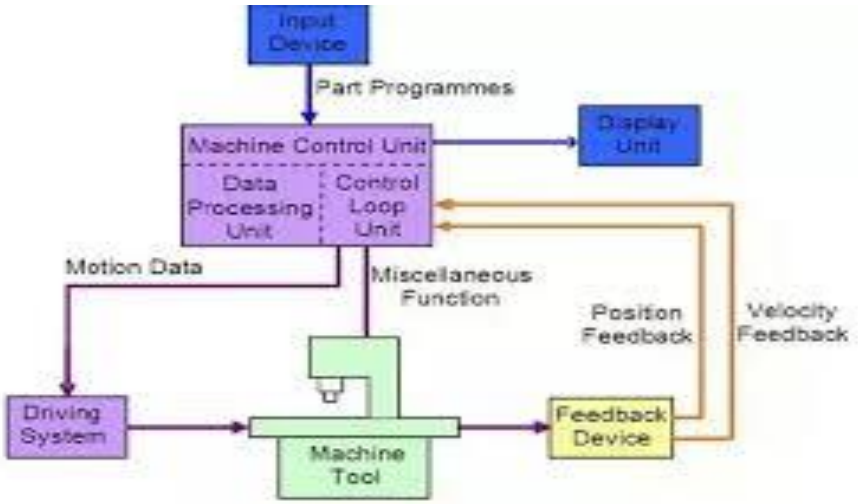
To decode the coded instructions.

To implement interpolations (linear, circular, and helical) to generate axis motion commands.

To feed the axis motion commands to the amplifier circuits for driving the axis mechanisms.

To receive the feedback signals of position and speed for each drive axis.

To implement auxiliary control functions such as coolant or spindle on/off and tool change.



(1.4) Drive System:

A drive system consists of amplifier circuits, drive motors, and ball lead-screws. The MCU feeds the control signals (position and speed) of each axis to the amplifier circuits. The control signals are modified to actuate drive motors which in turn rotate the ball lead-screws to position the machine table.

(1.5) Machine Tool:

CNC controls are used to control various types of machine tools. Regardless of which type of machine tool is controlled, it always has a slide table and a spindle to control of position and speed. The machine table is controlled in the X and Y axes, while the spindle runs along the Z axis.

(1.6) Feed Back System:

The feedback system is also referred to as the measuring system. It uses position and speed transducers to continuously monitor the position at which the cutting tool is located at any particular instant. The MCU uses the difference between reference signals and feedback signals to generate the control signals for correcting position and speed errors.

(1.7) Machine axes designation

Machine axes are designated according to the "right-hand rule", When the thumb of right hand points in the direction of the positive X axis, the index finger points toward the positive Y axis, and the middle finger toward the positive Z axis. Figure 10 shows the right-hand rule applied to vertical machines, while Figure 23.1 applies to horizontal machines.

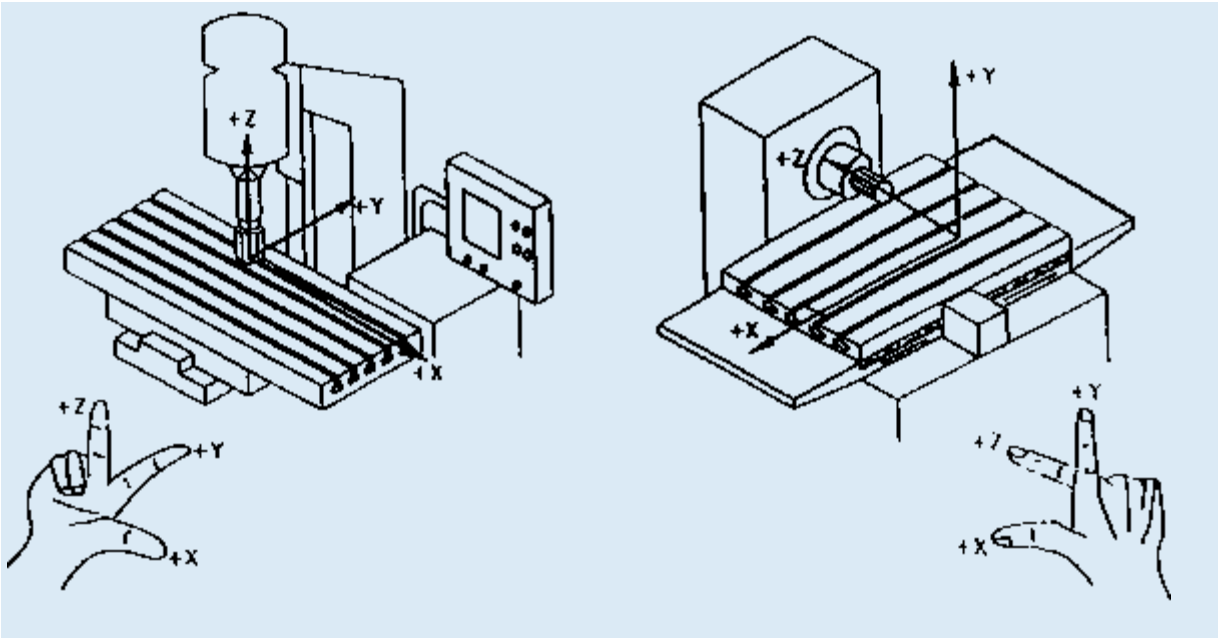


Figure 23.1: Right hand rule for vertical and horizontal machine

Comparison of conventional machine tools and CNC Machine tool

Following are the points of comparison between two machines

1. Precision Components: The digital template and autonomous machining of CNC practically eliminate human error and achieve accuracy within 1/1000th.

2. Reliable Endurance: CNC machines work around-the-clock daily, weekends and holidays. They only stop for needed maintenance or repair.

3. High Production: Once the design parameters and specification have been entered into a CNC machine, it consistently executes huge quantities while conventional machine.

4. More Capability: When used with advanced design software, CNC machines create outputs that cannot be done by manual machines. These machines can produce any size, shape or texture needed.

5. Less Labour: CNC machining requires fewer personnel to execute the production tasks. One skilled operator can run several of the autonomous CNC machines, and one programmer can get them loaded with the needed designs. A manual machine requires at least one skilled operator per machine plus usually a supervisor for the group.

6. Uniform Product: The advantage of CNC machine is that it provides uniformity in no. of parts made as compared with conventional machines.

7. Cost: The initial cost of CNC is high in comparison to conventional machine but high speed, efficiency, specialization, precision and fewer labour hours, add up good for business.

8. Better Safety: The operators involved in operating CNC machines, are at a distance from the sharp tools, whereas the operators of conventional-manual lathes, drills, punches and other tools come into direct contact.

9. Design Retention: Once a design has been loaded into the CNC machining software and a perfect prototype has been created, the program can easily retrieve the design to run it and create the object again. Additionally, there is no need to keep up with versions of the design that may exist on paper, a flash drive, a disk, other computer or elsewhere.

10. Versatility: CNC machine can produce components of different shapes, features easily as compared to conventional machine.

Constructional details CNC Turning and Machining Centre

There is a need for special consideration to be given to the design of CNC machine tools in the following areas:

(1) **Machine Structure.** The design and the construction of CNC machines should be such that it meets the following main objectives:

(i) **High Precision and Repeatability**. Accuracy or precision is the ability of a machine to produce desired dimensions. Repeatability is the ability to produce the same part for the same dimensions every time. Accuracy of a machine depends mainly on its control resolution which is the minimum distance between two points which the machine can differentiate. Repeatability is affected by mechanical errors such as backlash in the machine.

(ii) **Reliability.** It depends on the speed and load during operation as well as on the quality of the machine structure and control system.

(iii) **Efficiency.** The machine structure should be such that it should support all the machining operation stresses and strains with the capability of performing all type of operations in specified time.

(2) **Slide ways.** The design of slide ways in CNC machine tools should be:

(i) Reduced friction

(ii) Reduced Wear

(iii) Satisfy the requirements of movement of the slides

(iv) Improve smoothness of the drive

To meet these requirements in CNC machine tools slide ways, the techniques used include hydrostatic slide ways linear bearings with balls, rollers or needles and surface coatings.

(c) **Spindle Mounting.** In CNC machines, large variation in cutting speed is required. The cutting speed may vary from 10 metres per minute to 1000 meters per minute or more. The cutting speeds are provided by rotation of the main spindle with the help of an electrical motor.

(d) **Drive Units.** Drive motors are required to drive the main spindle (Spindle drive) and to drive the saddles or carriage (Axis drive). In addition there may be some motors in CNC machine for services such as coolant pumps, swarf removal, etc.

(e) **Elements of motion transmission and positional slides**. The conventional machines use Lead screw for motion transmission purposes. The Lead screw with acme

threads is not suitable for CNC machines due to higher friction between lead screw and the nut and poor power transmission efficiency and inaccuracy due to backlash. These problems have been overcome with the use of recirculating ball screw and nut arrangement. The advantage of using ball screw and nut assembly is:

(i) High efficiency

(ii) Reversibility

(iii) Wear and life

(iv) No stick slip

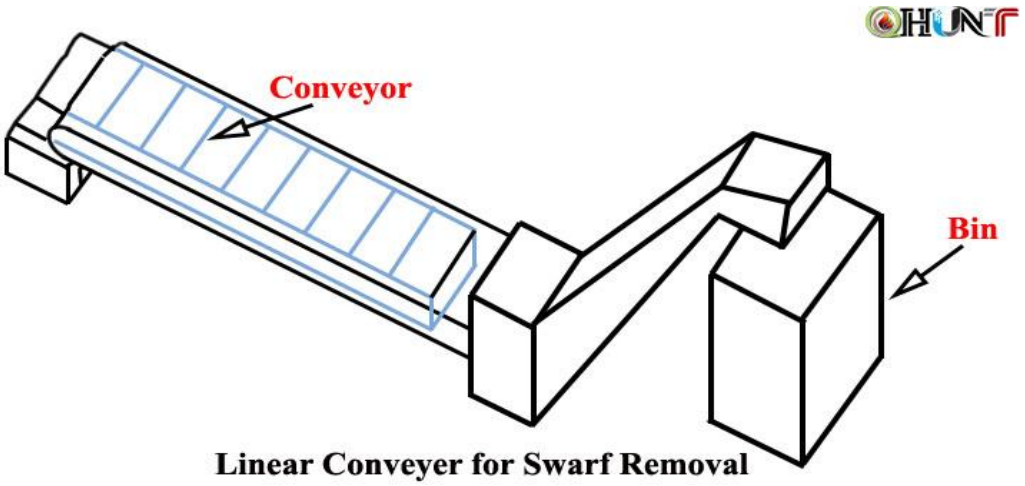
(f) **Location of transducers**. In CNC machines the control of all machine function is totally transferred to a computerized control system. The control unit should be situated so that it is convenient for the operator to operate the machine from the central place. The facilities which a control unit should offer are:

(i) Indicate the current status and position of various machine tool features and give feed back

(ii) Allow manual or semi-manual control machine tool elements.

(iii) Enable machine tool to be programmed.

(g) Swarf removal. CNC machines are designed to work at optimum cutting condition with the improved cutting tools on a continuous operation basis. Since the cutting time is much more in CNC machines, the volume of swarf generated is also more. Unless the swarf is quickly and efficiently removed from the cutting zone, it can affect the cutting process and the quality of the finished product. Also the swarf cannot be allowed to accumulate at the machine tool because it may hamper the access to the machine tool. In addition some auxiliary functions like automatic component loading or automatic tool change may also be affected by accumulation of swarf. To avoid these problems, an efficient swarf control system should be provided with the CNC machine tools with some mechanism to remove the swarf from the cutter and cutting zone and for the disposal of swarf from the machine tool area itself.



Linear Conveyer for Swarf Removal

(h) **Safety of operator**: Safety of operator is very important aspect which cannot be overlooked. To ensure safe working conditions the CNC machine tools are provided with metallic or plastic guards. Where it is not possible to provide effective guards, proximity protection is provided by perimeter guards, pressure mats or light barriers.

Slide ways and guide ways

The Guideway is one of the important elements of machine tool. The main function of the guideway is to make sure that the cutting tool or machine tool operative element moves along predetermined path. The machine tool operative element carries workpiece along with it. The motion is generally circular for boring mills, vertical lathe, etc. while it is straight line for lathe, drilling, boring machines, etc.

The friction between the sliding surfaces is called as guideways with sliding friction. These guideways are also called as slideways. The slideways are further classified according to the lubrication at the interface of contacting surfaces.

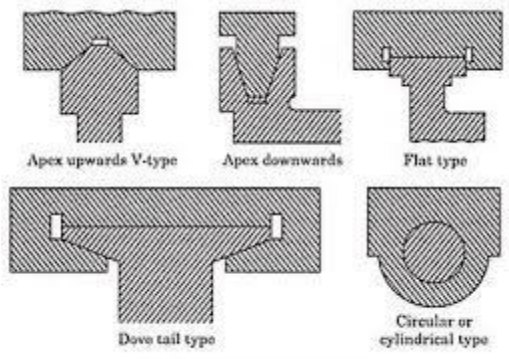


Fig. 11.17. Types of Slideways.

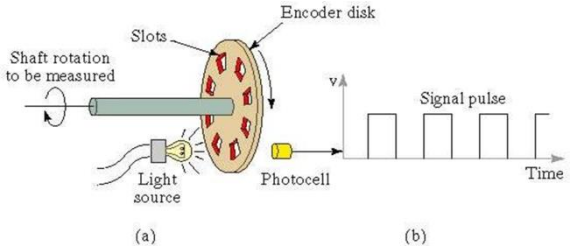
Feedback Devices

Two types of feedback devices normally used are:

1. **Positional Feed Back Devices**

1.1 Linear Transducers - a device mounted on the machine table to measure the actual displacement of the slide in such a way that backlash of screws; motors etc would not cause any error in the feedback data.

1.2 Rotary Encoders: It is a device used to measure the angular displacement. It cannot measure linear displacement directly so that error may occur due to the backlash of screw and motor etc.



2. **Velocity Feedback Device**

The actual speed of the motor can be measured in terms of voltage generated from a tachometer mounted at the end of the motor shaft. DC tachometer is essentially a small generator that produces an output voltage proportional to the speed. The voltage generated is compared with the command voltage corresponding to the desired speed. The difference of the voltages can is then used to actuate the motor to eliminate the error.

Safety devices

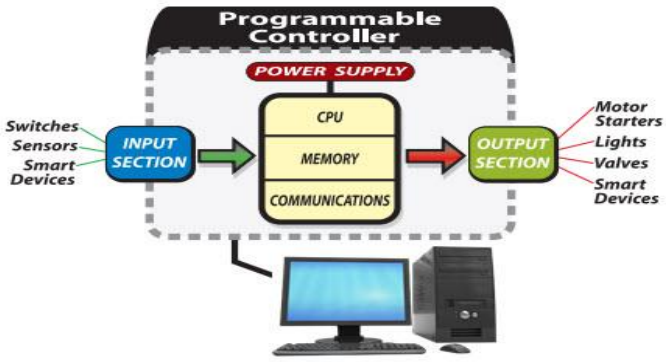
Some of these safety devices may include:

- **An Emergency Stop Button**
  The emergency stop button is used to shut down the machine instantly. This button is located on the handheld unit, the control panel, and other places on the machine.
- **A Soundproof Casing**
  The soundproof casing reduces the noise emitted by the operating section of the machine. It also protects the machine operator from the risk of flying tool fragments and any other flying objects.
- **The Curtain Guards**
  The curtain guards are made out of PVC. These are designed to shield the machine operator from the risk of tool fragments or airborne chips.
- **The Guard Fence**
  This part marks the maximum working area of the machine. This fence keeps the machine operator away from any moving parts.
- **The Contact Mats**
  The operator uses this control to stop the CNC machine instantly. When he or she stands on the mat the machine stops instantly. This protects the operator from the moving parts.

Programmable logic controllers(PLC)

Programmable Logic Controllers (PLC) are often defined as miniature industrial computers that contain hardware and software used to perform control functions. More specifically, a PLC would be used for the automation of industrial electromechanical processes, such as control of machinery on factory assembly lines,

amusement rides, or food processing. They are designed for multiple arrangements of digital and analog inputs and outputs with extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. A PLC will consist of two basic sections: the central processing unit (CPU) and the Input/Output (I/O) interface system.



- **CPU** –. They perform functions including logic operations, arithmetic operations, computer interface and many more.
- **Memory** –System (ROM) stores the data permanently for the operating system. RAM stores the information of the status of input and output devices, and the values of timers, counters and other internal devices.
- **I/O section** – Input keeps a track on field devices which includes sensors, switches.
- **O/P Section -** Output has a control over the other devices which includes motors, pumps, lights and solenoids. The I/O ports are based on Reduced Instruction Set Computer (RISC).
- **Power supply** – Certain PLCs have an isolated power supply. But, most of the PLCs work at 220VAC or 24VDC.
- **Programming device** – This device is used to feed the program into the memory of the processor. The program is first fed to the programming device and later it is transmitted to the PLC's memory.

Micro controllers

A microcontroller is a computer present in a single integrated circuit which is dedicated to perform one task and execute one specific application.

It contains memory, programmable input/output peripherals as well a processor. Microcontrollers are mostly designed for embedded applications and are heavily used in automatically controlled electronic devices such as cellphones, cameras, microwave ovens, washing machines, etc.