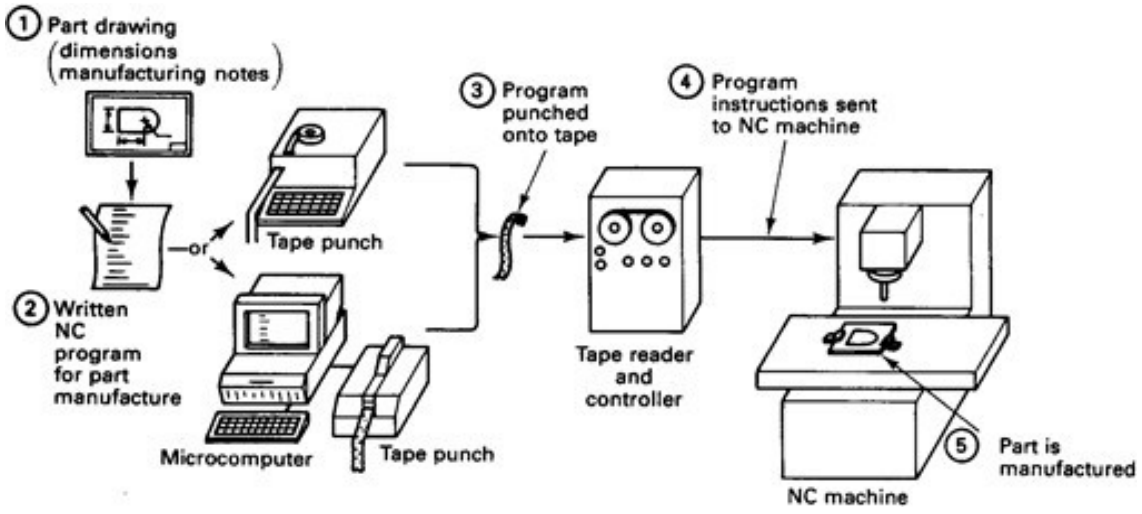
Week 01	Introduction to CNC Machines- Advantages of CNC machines over Conventional machines • Explain the Construction features of CNC machine- Machine Structure, bed, spindle motor and drive, axes motor and ball screws using Multimedia • Explain Guide ways, LM guides, console, control switches, coolant system, hydraulic system using Multimedia

Numerical control (NC) machine :

- Numerical control (NC) refer to control of a machine or a process using symbolic codes consisting of characters and numerals.
- 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.
- The word CNC came into existence when microprocessors and microcomputers replaced integrated circuit IC based controls used for NC machines.

Components of traditional NC systems :



CNC machine:

- 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.

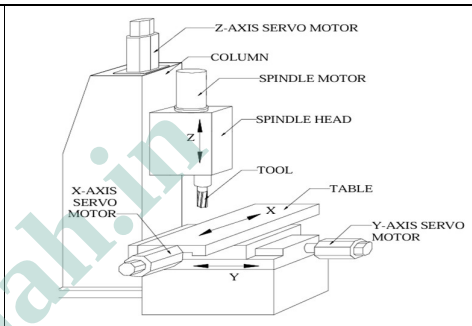


Fig. Sketch of a Numerically Controlled Machine Tool

Features of CNC-

Computer Numerical Control (CNC) systems include additional features beyond what is feasible with conventional hard-wired NC. Many of these features are standard on most CNC Machine Control units (MCU), include the following:

• **Storage of more than one part program:** With improvements in computer storage technology, newer CNC controllers have sufficient capacity to store multiple programs. Controller manufacturers generally offer one or more memory expansions as options to the MCU

• **Various forms of program input :** Whereas conventional (hard-wired) MCUs are limited to punched tape as the input medium for entering part programs, CNC controllers generally possess multiple data

entry capabilities, such as punched tape, magnetic tape, floppy diskettes, and manual data input (operator entry of program).

• **Program editing at the machine tool :** CNC permits a part program to be edited while it resides in the MCU computer memory. Hence, a part program can be tested and corrected entirely at the machine site, rather than being returned to the programming office for corrections. In addition to part program corrections, editing also permits cutting conditions in the machining cycle to be optimized. After the program has been corrected and optimized, the revised version can be stored on punched tape or other media for future use.

• **Fixed cycles and programming subroutines:** The increased memory capacity and the ability to program the control computer provide the opportunity to store frequently used machining cycles as macros that can be called by the part program. Instead of writing the full instructions for the particular cycle into every program, a programmer includes a call statement in the part program to indicate that the macro cycle should be executed. These cycles often require that certain parameters be defined, for example, a bolt hole circle, in which the diameter of the bolt circle, the spacing of the bolt holes, and other parameters must be specified.

• **Interpolation :** Some of the interpolation schemes are normally executed only on a CNC system because of computational requirements. Linear and circular interpolation are hard-wired into the control unit.

• **Positioning features for setup :** Setting up the machine tool for a given workpart involves installing and aligning a fixture on the machine tool table. This must be accomplished so that the machine axes are established with respect to the workpart. The alignment task can be facilitated using certain features made possible by software options in the CNC system. Position set is one of the features. With position set, the operator is not required to locate the fixture on the machine table with extreme accuracy. Instead, the machine tool axes are referenced to the location of the fixture using a target point or set of target points on the work or fixture.

• **Cutter length and size compensation:** In older style controls, cutter dimensions had to be set precisely to agree with the tool path defined in the part program. Alternative methods for ensuring accurate tool path definition have been incorporated into the CNC controls. One method involves manually entering the actual tool dimensions into the MCU. These actual dimensions may differ from those originally programmed. Compensations are then automatically made in the computed tool path. Another method involves use of a tool length sensor built into the machine. In this technique, the cutter is mounted in the spindle and the sensor measures its length. This measured value is then used to correct the programmed tool path.

• **Communications interface :** With the trend toward interfacing and networking in plants today, most modern CNC controllers are equipped with a communications interface to link the machine to other computers and computer driven devices. This is useful for various applications, such as:

(1) downloading part programs from a central data file;

(2) collecting operational data such as workpiece counts, cycle times, and machine utilization; and

(3) interfacing with peripheral equipment, such as robots that unload and load parts.

• **Diagnostics :** Many modern CNC systems possess a diagnostics capability that monitors certain aspects of the machine tool to detect malfunctions or signs of impending malfunctions or to diagnose system breakdowns

The advantages of CNC machines over Conventional machines include:

I. **Precision Components:** CNC machines are autonomous and adopt a digital template, which practically eliminates human error, translating into high accuracy. The software provides an end-to-end process, enabling it to produce repetitive actions flawlessly.

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

III. **Scalability:** CNC machines consistently execute the desired quantities and offer flexible scalability once you input the design parameters and specifications.

IV. **More Capability:** CNC machines create outputs that cannot be reproduced by manual machines when used in tandem with advanced design software. The machines can produce a variety of sizes, textures and shapes.

V. **Faster and Efficient Production:** CNC machines deliver quick results, making it simpler to meet high demands. They operate day and night, producing accurate outputs for industries. It helps industries increase their overall productivity.

VI. **Quicker Assembly:** CNC machines move human resources down the assembly line. This makes it possible for workers to manage high-production settings, which requires the specialized skills lacking in machine production. CNC machines produce seamless fitting parts, which allows the assembly line to flow freely.

VII. **Low Energy Consumption:** CNC machining is beneficial to industries engaged in automotive, oil and gas, aerospace and others known to be energy intensive. CNC machining reduces energy loss and decreases labor, providing a more sustainable alternative.

VIII. **Minimal Labor:** CNC machining requires less 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. What you save on manpower can be passed along to customers, helping you achieve a competitive advantage.

IX. **Uniformity:** CNC machines assure uniformity in all outputs. Even the most competent engineers on a conventional machine will produce components that vary slightly. With CNC machines, each part is a perfect match to the prototype's exact specifications.

X. **Lower Costs:** The collective result of efficiency, speed, specialization, precision and less labor hours benefits your business. The lower costs, in turn, can be used to create a competitive advantage and business re-investment. Saving money or making more money is one of the popular benefits of CNC machining.

XI. **Fewer Headaches:** Manual machining serves many good purposes, but it remains forever susceptible to the human element. You're probably familiar with the financial and cultural headaches it can cause when there are periods when you're short-staffed, have people out sick or on vacation and operators who don't perform to expectations. CNC machining nearly eliminates those concerning issues.

XII. **Better Safety:** Along with an expedient production process and consistent pieces comes a safer environment. While there are operators involved in operating CNC machines, it's at a distance from the sharp tools, whereas the operators of conventional-manual lathes, drills, punches and other tools come into direct contact with the implement.

XIII. **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. Regardless of external factors, such as machine-operator changes, the master file ensures the CNC machining process always produces a spot-on match. Additionally, there is no need to keep up with versions of the design that may exist on paper, a flash drive, a disk, another computer or elsewhere.

XIV. **Low Maintenance:** The G-code-based software will automatically update itself when needed, and CNC machines generally do not require much service other than to change the cutting implements at the proper interval and do some light cleaning. None of the regular maintenance requires professional service, which saves money.

XV. **Less Extensive Skill Required:** Conventional machines require manual experience and skill to execute tasks accurately. CNC does require some expertise to operate, as well. However, industries can produce high-quality products with relatively less skill in terms of actual parts creation.

XVI. **Increased Production Options:** CNC machining relies on advanced software, which makes it possible for manufacturers to produce items beyond their level of expertise. You can update the software to make add more operations and improve its functionality. You can use the same machine to execute several tasks, including emerging operations.

XVII. **No Prototype Required:** The CNC software allows you to manufacture products without necessarily creating a prototype first. This reduces cost and saves time. With CNC machining, you can also manufacture without recreating revisions to the prototype.

Constructional feature of computer numerically controlled (CNC) machine:

The design & construction of computer numerically controlled (CNC) machines differs greatly from that of conventional machine tools. Important parts and aspects of CNC machine's to be considered in their designing:

(a) Machine structure (b) Bed, (c) Guide ways (d) Spindle Motor and Drive (e) Spindle & spindle bearings (f) Controllers, software & operator interface (g) Measuring instruments (h) Gauging (i) Tool monitoring, (j) Axes Motors and Ball Screws

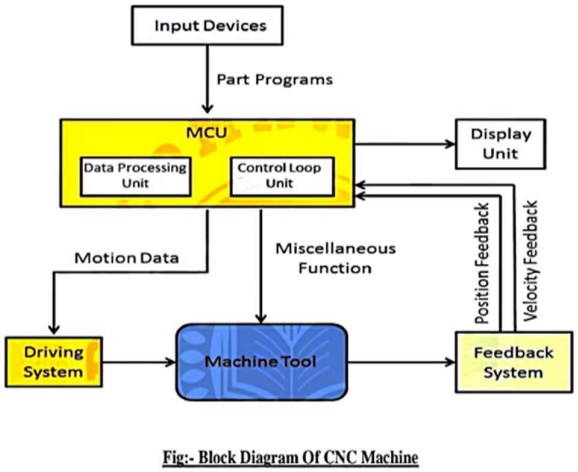


Fig:- Block Diagram Of CNC Machine

(a) Machine Structure: The Machine structure is the load carrying & supporting member of the Machine tool. All the motors, drive mechanism & other functional assemblies of machines tools are aligned to each other & rigidly fixed to the Machine structure. The Machine structure is subjected to static of dynamic forces & it is, therefore, essential that the structure does not deform or vibrate beyond the permissible limits under the action of these forces.

(b) Bed: The bed is made of very high-quality cast iron. It is the foundation for all other parts of the machine. The construction of the bed is such that it is strong enough to withstand heavy forces exerted by the cutting tool during cutting operations.

(c) Guide ways: Guide ways are used in Machine tools to:

I. Control the directions or lines of action of the carriage or the table on which a tool or a work piece is held.
II. To absorb all the static & dynamic forces.

(d) Spindle Motor and Drive:

- The spindle motor drives the cutting tool, such as a drill bit or milling cutter, to rotate at specific speeds.
- The spindle drive system transmits power from the motor to the spindle, ensuring precise control of the rotation.
- Electric motors, like stepper motors or servo motors, are commonly used to power the spindle and provide controlled speed and torque.
- The spindle's speed and direction can be programmed to match the machining process requirements.

(e) Spindle / Spindle Bearings: Material removal using single point or multi point work piece requires rotational speeds of the order of 30-6000 rpm and even higher. All work or tool carrying spindles rotating at these speeds are subjected torsional and radial deflections. They are also subjected to thrust forces depending on the nature of the metal cutting operation being performed. To in torsional strain on the spindles they are designed to be as stiff as possible with a minimum over hang. Also, the final drive to the spindle should be located as near as possible the bearings.

(f) Controls, Software & User Interface: CNC controls are the heart of the CNC MACHINEs. The early CNC controls were developed for simple applications in turning, machining centers & grinding. The new generation computer numerical controls allow simulations control of more axes, interpolate

positions faster, and use more data points for precise control. These processors perform multi tasks run one programming & simulating a second –which maximizes the Machine use.

(g) Measuring systems: On all CNC Machine, an electronic measuring system is employed on each controlled axis to monitor the movement & to compare the position of the slide & the spindle with the desired position.

Measuring systems are used on CNC Machines for:

(i) Monitoring the positioning of a slide on a slide way.
(ii) Orienting the spindle table & measuring the speed of the spindle.

(h) Gauging: Gauging on a Machine tool is basically used for work piece inspection, for defining tool off-sets & for tool breaking detection.

(i) Tool monitoring systems: A tool monitoring system monitors the tools wear & tool breakage.

(j) Axes Motors and Ball Screws:

- CNC machines utilize motors along each axis (X, Y, and Z) to control the movement of the machine table or head.
- Ball screws translate the rotational motion of the motors into linear movement, providing precise positioning.
- Stepper and servo motors are common choices for driving the axes, offering high precision and control. Ball screws minimize friction and ensure smooth, accurate movement along the axes.

CNC Machine Guide Ways

A CNC machine's structure, including its bed, spindle motor and drive, axes motors and ball screws, relies on several key components: guide ways, LM guides, the console, control switches, coolant system, and hydraulic system. These components work together to provide the precise, automated motion control necessary for machining.

1. Guide Ways and LM Guides:

Guide Ways: These are the rails or surfaces that the machine's moving parts (like the tool carriage or work table) slide along. They ensure accurate and smooth movement.

LM Guides (Linear Motion Guides): These are a type of guide way that utilizes rolling elements (like balls or rollers) to reduce friction and achieve high precision linear motion. They convert sliding motion into rolling motion, improving accuracy and reducing wear.

Structure: LM guides typically consist of a rail, a block (or carriage), and recirculating balls or rollers. Function: They guide the movement of the machine's moving parts along a straight line with high accuracy and repeatability.

Benefits: High precision, low friction, reduced wear, and suitability for high-speed machining.

Note: There are also non-rolling linear guide systems like those using air bearings.

Console and Control Switches:

Console: The console is the operator's interface, providing access to the machine's control system.

Control Switches: These are buttons, knobs, and other devices on the console that the operator uses to input instructions and control the machine's operations. They allow the operator to start, stop, and modify the machine's movements and settings.

Coolant System:

Function: The coolant system is used to cool the cutting tool and the work piece, as well as to remove chips from the machining area.

Components: Typically includes a coolant tank, pump, and nozzles to deliver coolant to the cutting zone.
Benefits: Reduces heat buildup, improves chip removal, and enhances tool life.

Hydraulic System:

Function: The hydraulic system provides power for certain CNC machine functions, such as clamping work pieces or operating auxiliary components.

Components: Includes a pump, reservoirs, valves, and actuators (like cylinders) to convert hydraulic pressure into motion.

Benefits: Provides high clamping forces, can actuate various machine functions, and offers reliable and efficient power transfer.