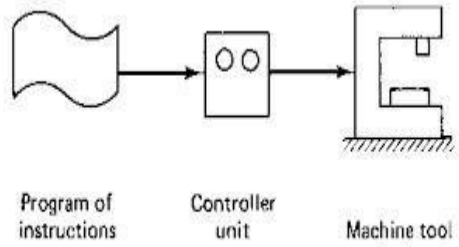
CO3	**Compare the constructional features of Numerical Control and Computer Numerical Control machines and develop part programs using ISO format for given simple components**		
M 3.01	Identify the components and processes and classification of NC and CNC machines	3	Understanding
M 3.02	Describe various preparatory and Miscellaneous functions in CNC part programming and develop a part program for the production simple components in turning, drilling and milling	8	Applying
M 3.03	Describe the principle, steps and applications of Rapid prototyping and 3D printing.	3	Applying

Contents: Basic concepts of NC and CNC machines-Introduction- construction details – classification: motion type, control loop system, axis- Components and their functions types of motion control - Automatic tool changer - tool magazine – types of tool magazine comparison of NC and CNC machines- Machining centers- machine axes conventions Programming CNC machines- Preparatory functions (M)- miscellaneous functions(G) structure of part programming- Part programming of machine simple turning, milling, drilling components. Rapid Prototyping (RP) in product design- application-steps - 3D printing- applications

NUMERICAL CONTROL: -Numerical control of machine tools may be defined as a method of automation in which various functions of machine tools are controlled by letters, numbers and symbols.

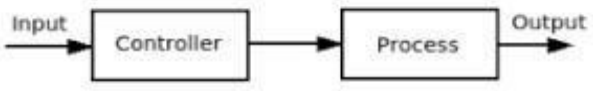


7.1 Three basic components of a numerical control system.

CLASSIFICATION OF N.C MACHINES: -

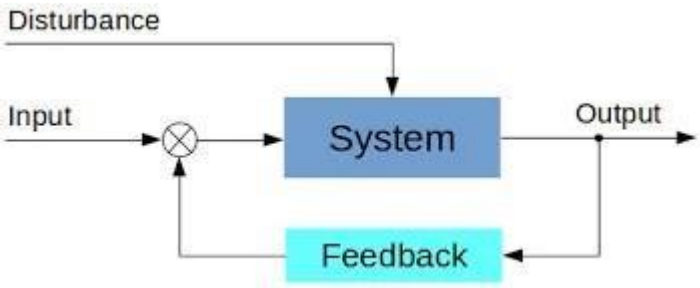
1. Based on feedback system

(a)Open-loop system: -In open-loop system, no feedback facility is provided. The input signal will be given to the machine tool. But during the process, if there is any difference in the actual process and specified process, no monitoring will occur.



Open Loop Control System

(b)**Closed loop system**: -A closed loo system is provided with feedback facility. So, the input signal is always monitored. So, during the process if there is any error, the feedback system will give signal to the control unit.

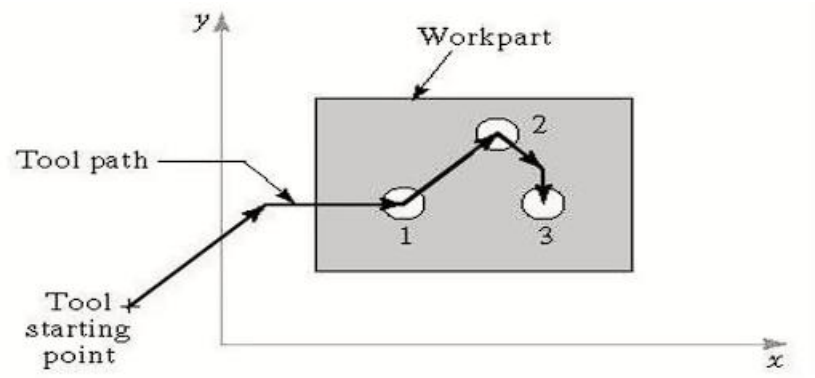


2. CLASSIFICATION BASED ON MOTION TYPE

1. Point-to-point system 2. Straight line system 3. Contour system

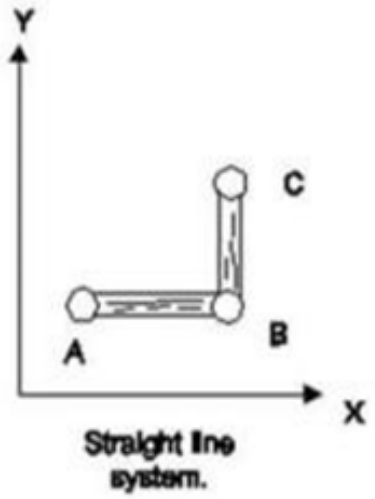
2.1 Point to point control system:

The work piece and the tool are placed in the position and the tool does its work. These types of machines are called point to point systems. The drilling, tapping and boring machines are characterized under these types. The work piece is not moved until the tool finishes the job and retracts to the safety. The point to point control system works as shown in the below figure.



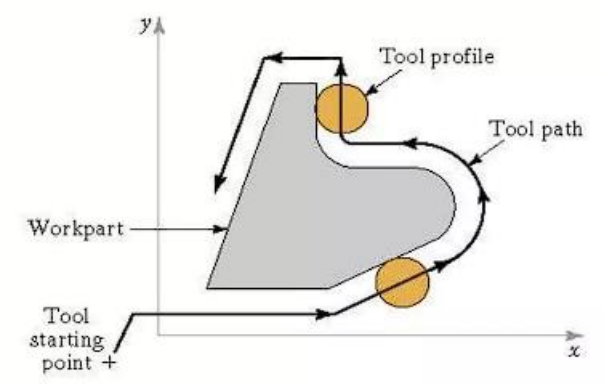
2.2 Straight Line System

The NC systems, in which the tool works along a straight line in the direction of a major coordinate axis, such as along the direction of feed during turning, boring or milling operation at a controlled rate, are known as Straight line control system.



2.3 Contouring system:

This type of machine tools works in a continuous path by cutting the material and following a contour of the part. These machine tools are known as contouring machines which includes Milling, lathe and routing machines. These contouring machines are also capable of doing the work same as point to point system. These contouring system machines require simulations movement of the tool and the work piece i.e., the positions of the work piece and the tool are simultaneously controlled by a control system. These machines are uneconomical if it's used as only point to control without continuous motions. The contouring motion works as below shown in figure.



3. CLASSIFICATION BASED ON AXIS TYPE

3.1 Two axis control system:

Two axis control system is a machine which give access to only two axis. The best example is the lathe machine. The machine driven with the servo motor allows you only two axis, i.e., X and the Z Axis.

3.2 Three axis control system:

Three axis control systems are the machines which moves in three dimensional i.e., X, Y and Z axis move simultaneously. These are the most popular machines which can produce high accurate precision parts with three axis machines.

3.3 Four **axis control system:**

In Four axis control system is a three-axis machine with an extra rotation on B-axis, four axis can be a vertical machine or an horizontal machine.In vertical CNC machine the rotary head is added on the side of the machine bed. The machine works as the three-axis machine but it has a rotary head for example if the holes have be machined on the tube, the tube can be mounted on the rotary B-axis and the drilling in the required angle. But vertical 4-axis machines are limited for the small jobs.

3.4 Five axis control system:

Five axis control system are the three axis machines with an extra rotation along Y and Z directions which are called B-axis and A-axis. As in Four axis machines B rotation is given by the bed and the A-axis rotation is given by the spindle movement called PIVOT point. Using a five axis machine reduces the cycle time by machining the complex parts in a single setup and improves the accuracy on the positional errors by eliminating the setups.

ELEMENTS OF NC MACHINE TOOLS

The main elements of a NC machine tool are

Control unit:-The instructions will be given to the control unit

Drive unit:-Signals from control unit passes to the drive unit. And these signals help to control the drive motor and control the movement like feed, travelling rate etc

Magnetic box:-Signals from control unit also passes to the magnetic box and these signals help to do the works like coolant supply, Spindle speed, On/Off of the motor etc

Machine tool:-The machine tool do the machining operations

Feed back system:-It monitor the errors in the process and send feed back to the control unit

Manual control unit:-Helps the operator to do some functions like motor start, coolant supply, speed change etc

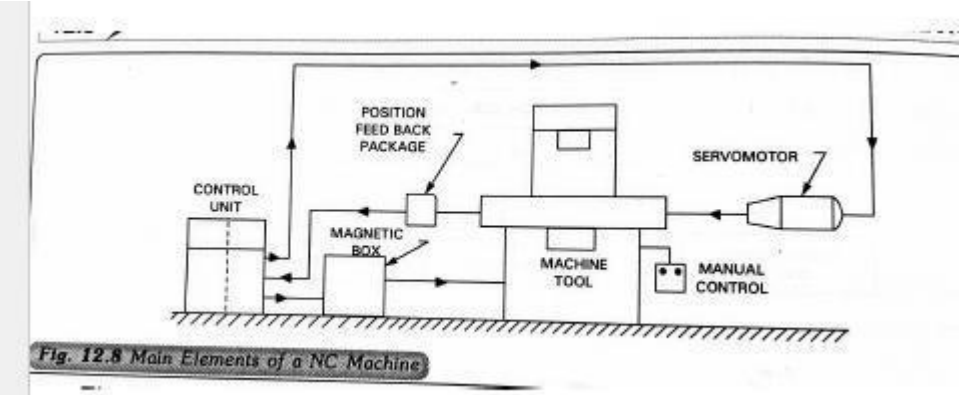


Fig. 12.8 Main Elements of a NC Machine

WORKING OF A NC MACHINE TOOL

Various steps involved are

1.Preperation of product drawing

2. Process planning

3.Programming

4.Tape preparation

5.Insert the tape to the control unit

6.Now as per the information getting from the control unit, the machine tool will be works and make the product

ADVANTAGES OF NC MACHINES: -

Complex shapes can be produced,

High accuracy, High flexibility,

Tool and work set up time will be less,

Productivity increases,

Mass production is possible,

Uniformity in production, Repeatability etc

DISADVANTAGES OF NC MACHINES:-

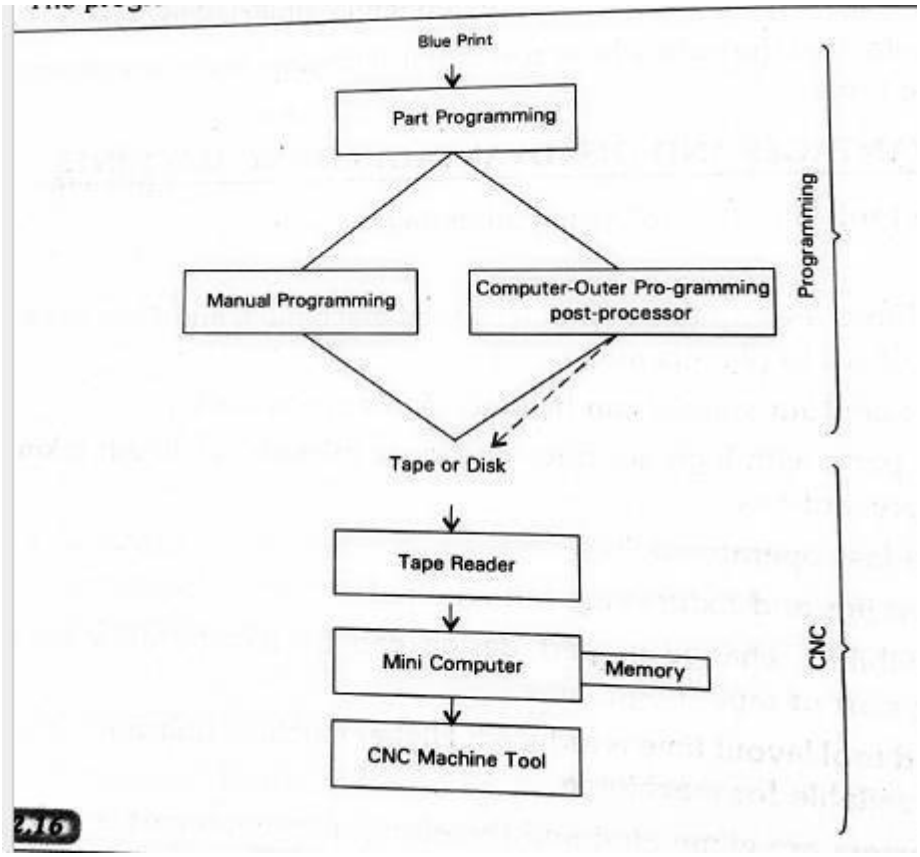
High initial cost,

Need of qualified programmers,

Only applicable for mass production etc

COMPUTER NUMERICAL CONTROL(CNC)

Controlling a machine or process by using programs which are prepared and store with the help of computer.



S.No.	NUMERICAL CONTROL (NC) MACHINE:	COMPUTER NUMERICAL CONTROL (NC) MACHINE:
1.	Input method: Punched tape, punched card and other such media.	Input method: programs are fed directly into the computer by small key board similar to our traditional key board.
2.	Programs should be changed in punched card and then fed to machine.	We can modify the program in computer.
3.	Operation parameters could not be changed.	Operation parameters can be changed.
4.	It has no memory storage.	We can store programs using the memory storage in computer.
5.	Run off the "Tape" each time of machine cycle.	It have the facility of running the program without actually running it ON the machine tool.
6.	NC machine cost is less.	CNC machine cost is high.
7.	Maintenance is less.	Maintenance is high.
8.	Accuracy is less.	It has more accuracy.
9.	High skill operator required.	High skilled not required.

AUTOMATIC TOOL CHANGER

An **automatic tool changer** (**ATC**) is used in computerized numerical control (CNC) machine tools to improve the production and tool carrying capacity of the machine. ATCs change tools rapidly, reducing non-productive time. They are generally used to improve the capacity of the machines to work with a number of tools. They are also used to change worn out or broken tools. They are one more step towards complete automation.

Tool magazine

The tool magazine system is a device for the storage and tool change required in the automated machining process of CNC machining centre. Through the control of the computer program, various processing requirements can be completed, such as milling, drilling, boring, tapping, etc., which greatly shortens the processing time and reduces the production cost, which is the biggest feature of the tool magazine system.

Rapid prototyping

Rapid prototyping is the fast fabrication of a physical part, model or assembly using 3D computer aided design (CAD). The creation of the part, model or assembly is usually completed using additive manufacturing, or more commonly known as 3D printing.

Different Types of Rapid Prototyping

1) Stereolithography (SLA) or Vat Photopolymerization

This fast and affordable technique was the first successful method of commercial 3D printing. It uses a bath of photosensitive liquid which is solidified layer-by-layer using a computer-controlled ultraviolet (UV) light.

2) Selective Laser Sintering (SLS)

Used for both metal and plastic prototyping, SLS uses a powder bed to build a prototype one layer at a time using a laser to heat and sinter the powdered material. However, the strength of the parts is not as good as with SLA, while the surface of the finished product is usually rough and may require secondary work to finish it.

3) Fused Deposition Modelling (FDM) or Material Jetting

This inexpensive, easy-to-use process can be found in most non-industrial desktop 3D printers. It uses a spool of thermoplastic filament which is melted inside a printing nozzle barrel before the resulting liquid plastic is laid down layer-by-layer according to a computer deposition program. While the early results generally had poor resolution and were weak, this process is improving rapidly and is fast and cheap, making it ideal for product development.

4) Selective Laser Melting (SLM) or Powder Bed Fusion

Often known as powder bed fusion, this process is favoured for making high-strength, complex parts. Selective Laser Melting is frequently used by the aerospace, automotive, defence and medical industries. This powder bed based fusion process uses a fine metal powder which is melted in a layer by layer manner to build either prototype or production parts using a high-powered laser or electron beam. Common SLM materials used in RP include titanium, aluminium, stainless steel and cobalt chrome alloys.

5) Laminated Object Manufacturing (LOM) or Sheet Lamination

This inexpensive process is less sophisticated than SLM or SLS, but it does not require specially controlled conditions. LOM builds up a series of thin laminates that have been accurately cut with laser beams or another cutting device to create the CAD pattern design. Each layer is delivered and bonded on top of the previous one until the part is complete.

Applications

Product designers use this process for rapid manufacturing of representative prototype parts. This can aid visualisation, design and development of the manufacturing process ahead of mass production.

Originally, rapid prototyping was used to create parts and scale models for the automotive industry although it has since been taken up by a wide range of applications, across multiple industries such as medical and aerospace.

Rapid tooling is another application of RP, whereby a part, such as an injection mould plug or ultrasound sensor wedge, is made and used as a tool in another process.

3D printing

3D printing, also known as additive manufacturing, is a revolutionary technology that allows the creation of threedimensional objects by adding material layer by layer. It is a departure from traditional subtractive manufacturing processes, where material is removed from a solid block to create the desired shape. In 3D printing, objects are built up layer by layer from digital 3D models, offering numerous advantages and applications.

Key Components of 3D Printing:

1. Digital 3D Model: The process starts with a digital 3D model created using computer-aided design (CAD) software or obtained from 3D scanning.

2. 3D Printer: The 3D printer is the machine that executes the printing process. It reads the digital model and deposits material layer by layer to create the physical object.

3. Printing Material: Various materials can be used for 3D printing, including plastics, metals, ceramics, and composites, depending on the printer type and application.

4. Printing Process: 3D printing encompasses various printing technologies, such as Fused Deposition Modelling (FDM), Stereolithography (SLA), Selective Laser Sintering (SLS), and more