CNC Machines

Learning Objectives

- Students to know how the machines are controlled by numerical control.
- To know about the computer numerical control machines, its elements and functions of elements.
- To know about the classification of CNC machines in detail.
- To know about the programme of CNC machine.

Nandrikku viththaagum nallozhukkam theeyozhukkam
Endrum idumbai tharum.   − kural 138

Property of conduct is the seed of virtue; impropery will ever cause sorrow.

CONTENTS

9.1 Introduction

Production is a process of converting raw material into finished products. The process of productions is achieved by the collective efforts of man and machine using materials and tools. It requires information and energy to accomplish production by machining. Over the period of time, several techniques and methods are used in the process. The evolution of new methods of production saw the increasing involvement of machines in providing the information and energy required for production and the role played by the humans declined.

Prepared programs consisting of information and instructions took the role of controlling the machines instead of manual control. This has led to a manufacturing system of higher production at lower cost with more accuracy.

CNC Machine

9.2 Numerical control

In NC system, intervention of human beings in the machining process is substituted by some operating instructions in a coded form. This coding, otherwise known as part program, is stored in cards or tapes. Getting the required instructions from these input media, the machine carries out different tasks in a proper sequence.

Numerical control can be defined as a system in which actions of a machine tool are controlled by recorded informations in the form of numerical data.
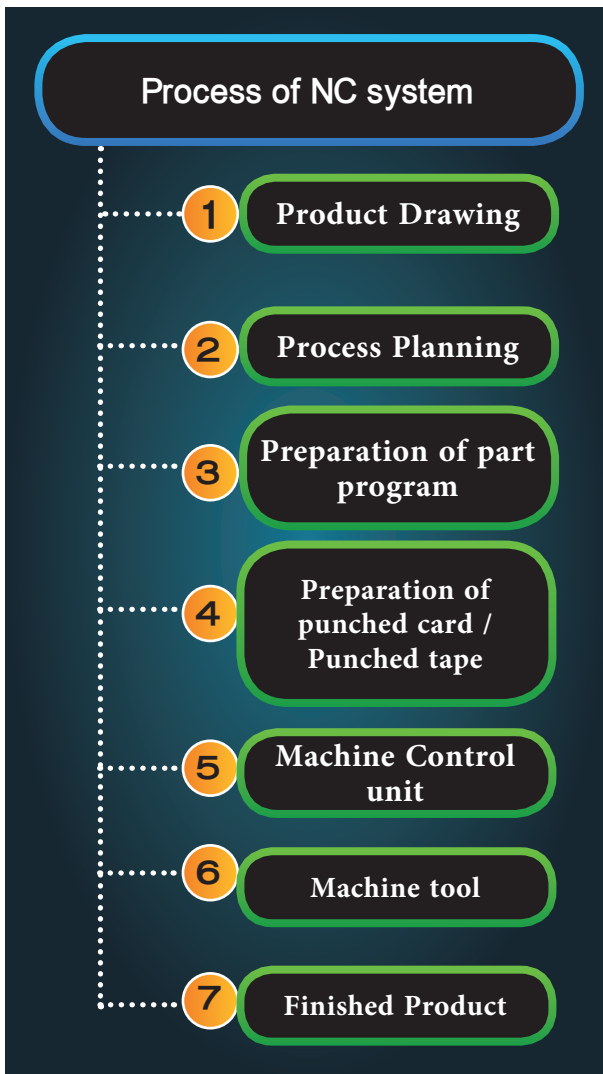
9.3 Computer Numerical Control

When the activities of a numerical control machine is administered by a computer, it is known as computer numerical control machine tool. The functions of the machine tool are controlled by the instructions stored as programs in the computer.

9.4 Elements of CNC machines

As explained earlier, the NC system requires the preparation of part program based on the product drawing, preparation of input media (punched cards & punched tapes), the data entry into the control unit, consequent processing and actuation of the machine tool to produce the desired part.

To perform all the above operations the NC machine have the following elements

1. Software
2. Machine control unit
3. Driving devices
4. Machine tool

Process of NC system

1. Product Drawing
2. Process Planning
3. Preparation of part program
4. Preparation of punched card / Punched tape
5. Machine Control unit
6. Machine tool
7. Finished Product

1. Punched cards
2. Punched tapes
3. Magnetic tapes
4. Floppy disks

Punched cards and punched tapes are useful in storing data in the form a series of punched holes. Punched tapes may be made of paper, plastic or aluminium foils. Magnetic tapes are made of plastic material and coated with Gamma ferric oxide layer. Magnetic tapes may be used for storing more informations and it may erased and reused.

9.7 Machine Control Unit (MCU)

Machine Control Unit consists of electronic circuits (hardware) that are useful in reading and interpreting the instructions (NC program) fed by means of input media and convert them into mechanical actions of the machine tool.

There are three types of MCU. They are

A. Inbuilt type
B. Swivel type
C. Stand alone type

A. Inbuilt MCU

When the control unit of the NC machine is mounted in the construction of the machine itself, it is known as Inbuilt MCU. Inbuilt MCU is shown in figure.

Inbuilt MCU

9.5 Software

Software of a NC system can be referred to items comprising of instructions, (programs) computer languages used for write these programs and a variety of input media.

In order to provide informations into the control unit or a computer, binary format is used. In this system, only two digits 0 and 1 are used.

9.6 Input Media

Different types of input media are used to store informations and to provide input to various control units of the NC machine. They are

B. swivel MCU

The MCU is a separate unit and is connected to the machine by swinging arrangements. The MCU as a whole can be swing around the machine depending upon the position of the operator. Swivel MCU is shown in figure.
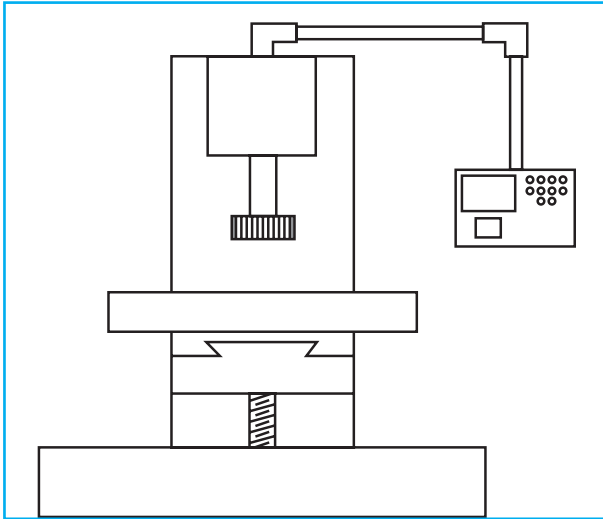
Swivel MCU

C. Stand alone MCU

Stand alone MCU is designed as a separate unit and placed at a distance from the machine. Stand alone MCU is shown in figure.

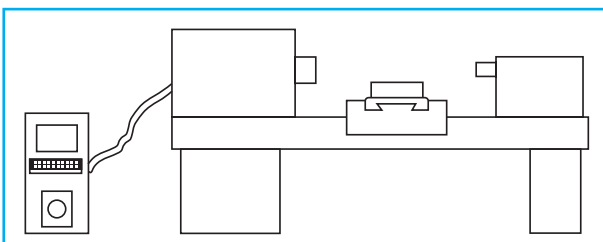

Stand Alone MCU

Elements of a machine control unit

A machine control unit consists of following elements

1. Input reading unit
2. Memory unit
3. Processing unit
4. Output unit
5. Feedback unit

Input Reading Unit

It is a electromagnetic device useful in reading the NC programs in the form of instructions.

The main functions of an input reading unit are

1. To accept the input media
2. To collect the input media instructions.
3. To send them into processing unit.
4. To keep the input media safety for reuse.

Memory Unit

The information received from input reading unit will be saved in memory unit. It will be send to processing unit, when it is required.

Processing Unit

The informations received from the memory unit are processed here and are given to various parts of the CNC machine. The processing unit serves as a link between the memory unit and output unit.

Output Unit

The wires coming out of the processing unit are called output unit. This output unit emit electric pulses of low voltage. In order to drive various slides of the machines, the pulses are amplified by means of electronic or electro-magnetic amplifiers.

Feedback Unit

Feedback unit consists of some electrical or electronic hardware. This is used for converting physical quantities like displacement and velocity into electrical pulses.

Process of a NC Machine Tool

Conversion of raw materials into components

Machine tool

Driving devices

Feedback unit

Conversion of slide movements into electric pulses

Output unit

Processing unit

Machine control unit

Memory unit

Input Reading unit

Input media

Punched card Punched tape

9.8 Driving devices

Driving devices consist of different types of motors and gear trains. They convert the instructions from MCU, into accurate mechanical displacements of the machine tool slides.

Servomotor, stepper motor, synchros and resolver are different types of motors used as drives in NC machines.

9.9 Machine tool

Machine tool is the machine which converts the raw materials into finished components. It is designed to perform various machining operations.

It consists of a machine table, spindles, cutting tools, work holding devices such as jigs and fixtures, coolant systems, swarf removal systems and other auxiliary equipments.

9.10 Classification of CNC Machine tools:

CNC machine tools are classified as follows

1. According to the type of power to the drives
   a. Electrical
   b. Hydraulic
   c. Pneumatic

2. According to motion control system of slides
   a. Point-to-point System
   b. Continuous path system

3. According to the feedback system
   a. Open loop system
   b. Closed loop system

4. According to number of axis
   a. 2 – axis
   b. 3 – axis
   c. 4 – axis
   d. 5 – axis

Motion control unit

The cutting tool and the work are located at certain positions in NC machine. During the machining, they are moved from their positions with relation to each other. This system is known as "motion control system"

Point to Point motion control system

Machining is performed only after the cutting tool and the works are located (positioned) at defined positions and there will not be any change in their positions during machining. This system is also called positioning system for this reason.

The relocation is achieved by their movement in two main axes (x axis and y axis). This is the reason for this system to be called as point-to-point system. This system is used in drilling machines, jig boring machines and spot welding machines.

Continuous path motion control system

In this system, both the cutting tool and the work change their positions depends all axes during machining. This system is also called as 'contouring system' and is mainly used in milling machine.

Feed back control system

The actual output movement of NC machines is compared with the desired value as given in the input media. This type of control system is called as "feedback control system".

Types of CNC Machine

1. According to the type of power to the drives
- a. Electrical
- b. Hydraulic
- c. Pneumatic

2. According to motion of control system of slides
- a. Point to point system
- b. Continuous path system

3. According to the feedback system
- a. Open loop system
- b. Closed loop system

4. According to the number of axis
- a. 2 axis
- b. 3 axis
- c. 4 axis
- d. 5 axis

Open loop system

When a NC system does not have any feedback arrangement, it is known as 'open look system'. In this system actual output movement of spindle and table is not compared with the desired movement given by input media.

Closed loop system

The movements of spindle and sliders are measured and compared with the values given by input media. If the output values are not matched with input values, the difference is corrected in machine control unit of NC machine. This system is used where the higher accuracy is required.

9.11 Advantages of CNC machines over conventional machine tools

1. The process of production, planning becomes easy.

2. The production of a single CNC machine is equivalent to production of many conventional machine tools. So the time is lesser.

3. As a single CNC machine is doing many machine functions, it is not necessary to buy many machines. It ensures reduction of floor space.

4. The time required for making input media is very less, when compared with making jigs and fixtures.

5. Smaller quantities of production is possible so keeping low raw material is enough

6. The design change of the component can be done easily and quickly

7. As the CNC machines require very little attention of the operator, the machine utilization is better

8. Jigs and fixtures are not used in CNC machines. It reduces the tooling costs.

9. In a single set up of tool and work piece, many operations are done. So the time is saved

10. Due to higher accuracy, it leads to better assembly and reduces fitting costs. The quality of the product also becomes better.

11. Operators errors are less, so wastage is also less

12. As a single operator can supervise several machines at a time, the labour cost is reduced.

9.12 Programming for CNC Machines

Based on the component drawing, a lot of information are need to be fed into the control unit for processing and machining. The informations include dimensions, shape, cutting speed, feed, depth of cut, sequence of operations, tool and work material. The said information should be fed into the machine control unit in an acceptable form. Preparation of the instructions in the above form is known as 'programming'.

Part Program

A series of instructions describing the part to be produced in an acceptable form to the control unit or computer is known as part program. Generally part programming is done be the following methods.

1. Manual assisted part programming

2. Computer assisted part programming

   APT (Automatically programmed tools), ADAPT, EXAPT, SPLIT, PROMPT are some of the high level languages for writing NC programs.

a. Main frame computer
b. Bulk memory
c. Network system
d. NC machine tools
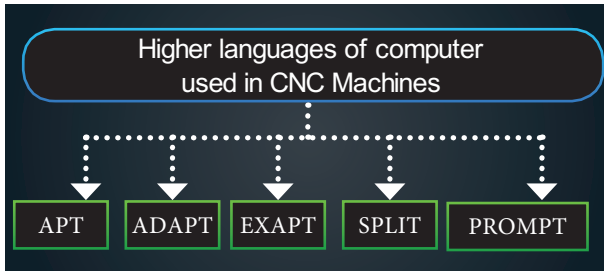
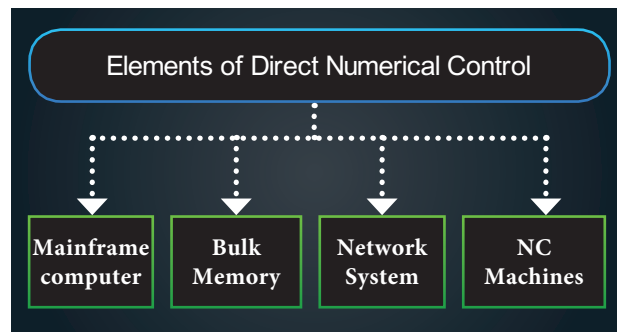## 9.13 Advancements in NC machines

After the modern micro-processor based computers took control of the NC system, the technology in this field has grown tremendously. Following are two major advancements of NC system.

1. Direct Numerical control(DNC)
2. Adaptive control(AC)

Direct Numerical control (DNC)

A manufacturing system in which several NC machines are connected to and controlled by a remotely located main frame computer is known as 'Direct Numerical Control' (DNC). The basic constituents are

DNC system eliminates the need of separate machine control units, input media, this system governs the scheduling of work of all the NC machine tools. The required network system may be a LAN (Local Area Network) or WAN (Wide Area Network)

Adaptive control

During machining, cutting speed, feed and depth of cut are measured and compared with desired values.

If it is not so, it will adapted (modified), then it is called as "Adaptive control".

ACTIVITIES

1. Students to visit the polytechnic, Engineering colleges for showing the CNC machines and its functioning.

Questions

Part I.
Choose the correct option 1 Mark

1. Production is achieved by
   a) man and machine
   b) materials and tools
   c) men, machine, materials and tools
   d) men and tools

2. In NC system the program instructions are given as,
   a) Information
   b) numerical data
   c) symbols
   d) thread symbols

3. IC refers to

a) Information control

b) Instruction control

c) Internal control

d) Integrated circuits

4. When a NC system does not have any feed back arrangement, it is known as

a) Positioning system

b) contouring system

c) closed loop system

d) open loop system

Part II.
Answer the following questions in one or two sentences   3 Marks

5. Define "Numerical control".

6. What are the types of Machine control unit?

7. Mention any three types of elements in Machine control unit.

8. What are the functions of input reading unit?

Part III.
Answer the following questions in about a page   5 Marks

9. Draw a flow – chart of NC system.

10. Explain "Input Media"

11. Explain with neat sketch any one types of Machine control unit.

Part IV.
Answer the following Questions in detail.   10 Marks

12. Draw a flow-chart of "Machine Tool"

13. What are different types of CNC machines? Explain "point to point motion control system".