# INTRODUCTION

A manufacturing system consists of all the resources required to transform the material from its raw form to finished form. The resources involved in this transformation process may be man, materials,money, machine, management, energy, etc.

A manufacturing system's components may be broadly categorized as follows:

- Production machines, tools, jigs, fixtures, etc.
- Material handling systems.
- Computer systems.
- Human resources.

## NUMERICAL CONTROL (NC)

Numerical control can be defined as a form of programmable automation in which the machining process is controlled by numbers, letters, and symbols. NC technology has been applied for a wide variety of operations but principal application is in machining operations.

An operational NC system consists of the following three basic components:

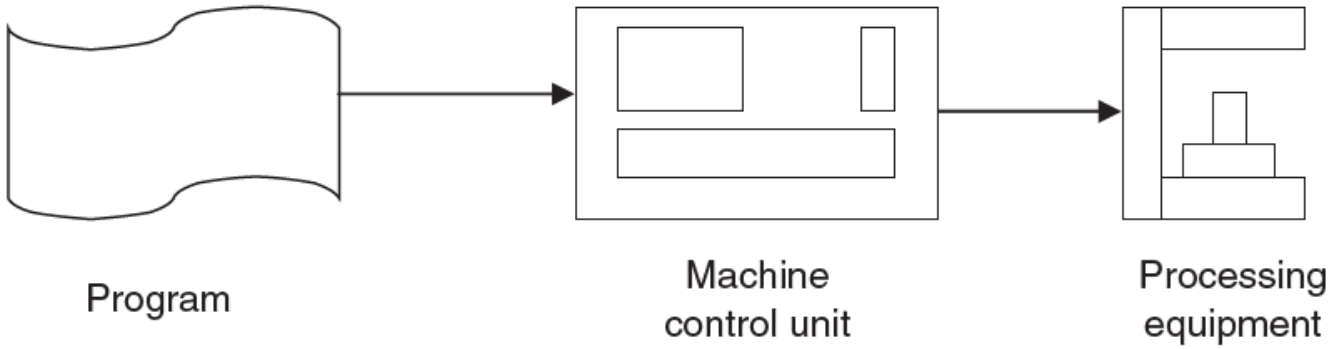
- Program of instruction.
- Controller unit.
- Machine tools.

## NUMERICAL CONTROL (NC)

- **The program of instruction** consists of details of sequence of operations in symbolic, numeric, or alpha numeric form on some medium like tape, which can be interpreted by controller unit.
- **Controller unit** consists of the electronics and hardware that read and interpret the program of instructions and convert it into mechanical actions of the machine tool.

# NUMERICAL CONTROL (NC)

- The typical elements of conventional NC controller unit include the tape reader, a data buffer, signal output channels to the machine tool, feedback channels from the machine tool, and the sequence control to coordinate the overall operation of the forging element.
- Machine tool is the part of NC system which performs useful work. It also includes the cutting tools, work fixtures, and other auxiliary equipment needed in the machining operation. The three components of NC system are shown in Figure



## Limitations/Drawback of Conventional NC System

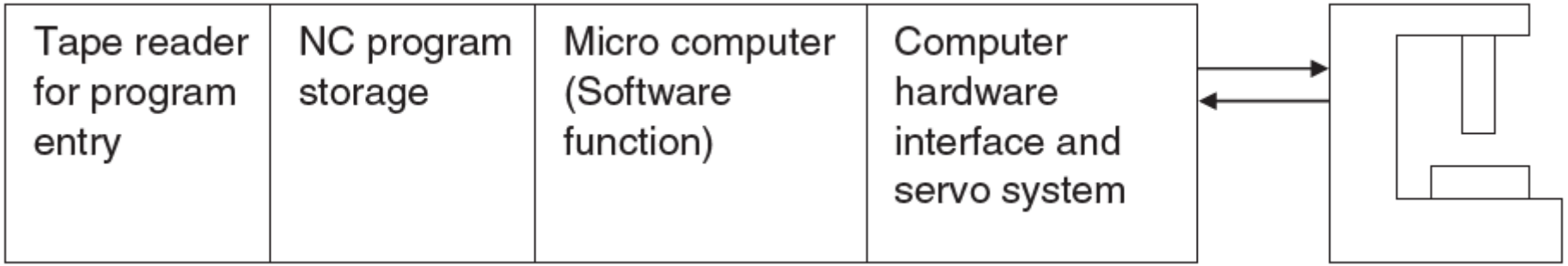
- ❑ Part programming mistakes in punched tape are common.
- ❑ Short life of punch tape due to wear and tear.
- ❑ Less reliable tape reader component.
- ❑ Less flexible hard wired controller unit.
- ❑ Non-optimal speed and feed.

## COMPUTER NUMERICAL CONTROL (CNC)

- The appearance of CNC system is very similar to NC system but the way of using the program is different.
- In a conventional NC system, the punched tape is cycled through the tape reader for each work part in the batch.
- The machine control unit reads in a block of instructions on the tape executing that block before proceeding to the next block. In CNC, the entire program is entered once and stored in computer memory.

## COMPUTER NUMERICAL CONTROL (CNC)

- The machining cycle for each part is controlled by the program contained in memory rather than from the tape itself. The general configuration of CNC system is shown in Figure




Components of CNC Systems

## COMPUTER NUMERICAL CONTROL (CNC)

Following features are associated with CNC system:

- ❑ Storage of more than one program.
- ❑ Program editing at the machine tool site.
- ❑ Fixed cycles and programming subroutines.
- ❑ Interpolation.
- ❑ Positioning features for setup.
- ❑ Cutter length compensation.
- ❑ Diagnostics.
- ❑ Communication interface.

# CNC-PROGRAMMING METHODS

**Manual Part Programming:** Manual part programming is the oldest method and still quite popular.This technique requires the programmer to examine a part drawing then 'manually' calculate all tool paths. This information is recorded on a manuscript. A punched tape is prepared from the manuscript.

**Computer Assisted Part Programming:** In computer assisted part programming, much of the tedious work required to calculate tool offsets, partial arcs, and the geometry of the part, is performed by the computer. When using computer assisted part programming, the programmer utilizes a high level language to describe part geometry and cutter path with respect to the geometry, then the computer performs all necessary calculations and generates tool path information. This tool path data is then post-processed into the format required for a specific CNC machine tool. For complex parts, computer assisted part programming may be necessary and the savings in programming time can be substantial.

# CNC-PROGRAMMING METHODS

**Computer Aided Drafting/Computer Aided Manufacturing:** This method of programming machine tools is sophisticated and growing in popularity. As CAD/CAM software systems become more user friendly, inexpensive, and reliable, more and more manufacturers are turning to CAD/CAM for part programming. Essentially, CAD/CAM enables a programmer to manipulate CAD data so CAM software is capable of understanding the data. Once properly manipulated, the CAM software performs all necessary calculations and generates CNC tool path data that are made to part-processed for a variety of machine tools.

# CNC-PROGRAMMING METHODS

**Conversational and Shop Floor Programming:** Conversational programming is an interactive method of generating CNC code. The CNC programmer or machine tool operator answers questions and provides data about tool paths when prompted by a conversational programming software system. These answers to questions and associated data are translated into a CNC program for a particular machine tool. Often these conversational systems reside on the machine tool controller and the interaction (programming) is done on the shop floor, hence, the term shop floor programming. This method of programming is generally restricted to relatively simple geometry.

**Parametric Programming:** An enhancement to the methods above more so than a method in and of itself, parametric programming software systems enable the programmer to describe part geometry using variables. Once described, entering specific values for the variables that uniquely identify the part generates an actual tool path CNC program.

# Advantages of CNC System

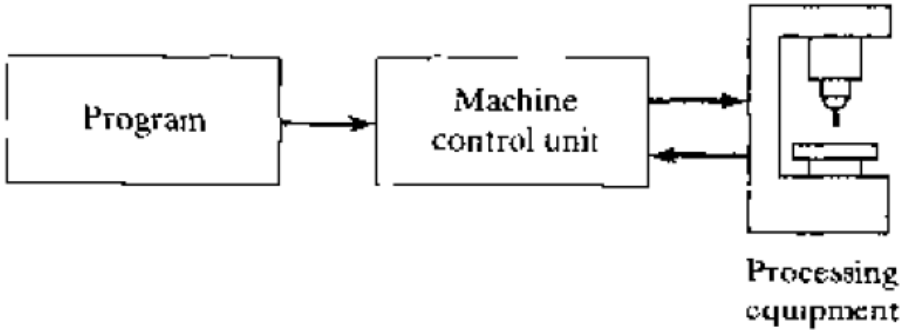
- **Increased Precision and Accuracy:** CNC machines utilize digital computer programs for precise control of machine movements, resulting in higher accuracy and repeatability compared to NC machines which rely on punched tape. This leads to tighter tolerances and fewer errors in the finished product.
- **Enhanced Flexibility and Adaptability:** CNC machines can easily switch between different tasks and designs because programs can be modified on the computer without needing to alter physical tapes. NC machines require manual reprogramming for each change, which can be time-consuming and prone to errors.
- **Higher Automation and Efficiency:** CNC machines automate the machining process, reducing the need for manual intervention and minimizing human error. This leads to faster production cycles and increased throughput.
- **Reduced Labor Costs:** Due to the higher degree of automation, CNC machines require less operator intervention, resulting in lower labor costs.

# Advantages of CNC System

- **Improved Consistency and Quality:** CNC machines consistently produce parts to the same specifications, ensuring high quality and minimizing variations.
- **Faster Production of Complex Designs:** CNC machines can handle complex designs and geometries with ease, thanks to their advanced programming capabilities. Streamlined Production Processes: CNC machines enable efficient production processes through their ability to store and reuse programs, allowing for rapid setup and changeovers.
- **Effective Prototyping:** CNC machines are well-suited for prototyping due to their flexibility and ability to quickly adapt to design changes.

## BASIC COMPONENTS OF NC SYSTEM

- The program of instructions is the detailed step by step commands that direct the actions of the processing equipment.
- In machine tool applications, the program of instructions is called a **part program**.
- The individual commands refer to positions of a cutting tool relative to the worktable on which the workpart is fixtured. Additional instructions are usually included such as spindle speed, feed rate, cutting tool selection and other functions.




| NC Part Program Code | Comments |
|---|---|
| N001 G21 G90 G92 X0 Y-050.0 Z010.0; | Define origin of axes. |
| N002 G00 X070.0 Y030.0; | Rapid move to first hole location. |
| N003 G01 G95 Z-15.0 F0.05 S1000 M03; | Drill first hole. |
| N004 G01 Z010.0; | Retract drill from hole. |
| N005 G00 Y060.0; | Rapid move to second hole location. |
| N006 G01 G95 Z-15.0 F0.05; | Drill second hole. |
| N007 G01 Z010.0; | Retract drill from hole. |

## CNC MACHINING CENTRES

- A machining centre is a computer controlled machine capable of performing a variety of cutting operations on different surfaces and directions on a workpiece.

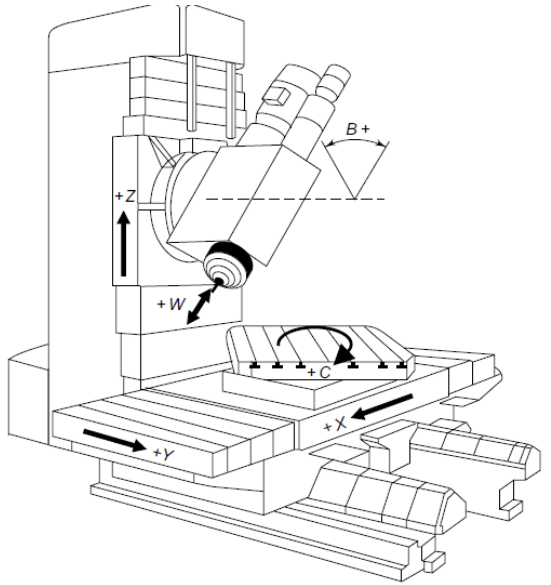
- The CNC machining centres can be broadly categorised into two varieties:
  - Vertical axis machining centre, and
  - Horizontal axis machining centre.

## VERTICAL AXIS MACHINING CENTRE

- The vertical axis machining centres or VMC as is popularly abbreviated, are generally more versatile in terms of the tool being able to generate more complex surfaces compared to the horizontal axis.

- Most of the general machines come with 3 axes. Additional axes will be added to cater to the machining of more complex geometries.

- For example the spindle head can be swivelled in one or two axes (about X or Y axis). These are required for machining sculptured surfaces.



## HORIZONTAL AXIS MACHINING CENTRE

- By its very configuration, the horizontal axis machining centre or popularly called HMC is sturdier than the vertical configuration and hence is used for heavier work pieces with large metal removal rates.

- Since these machines provide for heavier metal removal rates, the cutting tools used would normally be big. As a result, the tool magazine will have to provide larger place for each tool.

- This results in the tool magazines for HMC to become heavier. Also, they are normally provided with tool magazines having higher capacity.

## CNC TURNING CENTRE

- Majority of the components machined in the industry are of the cylindrical shape. Hence the CNC lathes, more appropriately called turning centres, are also important machine tools.

- The major change to be noticed in the turning centres is the early adoption of the slant bed to allow for a better view of the machining plane as well as for easy placement of the various devices involved in the machining zone.

- Most of the turning centres are also provided with a tool turret which may have a capacity of 8 to 12 tools of various types.