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# UNIT 3 CNC MACHINE TOOLS

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## 3.1 INTRODUCTION

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CNC machines, DNC machines, Advantages and disadvantages of CNC machines, Parts suitable for CNC machines and Environmental control for CNC machines are described in this Unit.

### Objectives

After studying this unit, you should be able to understand

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## 3.2 COMPUTER NUMERICAL CONTROL (CNC) MACHINES

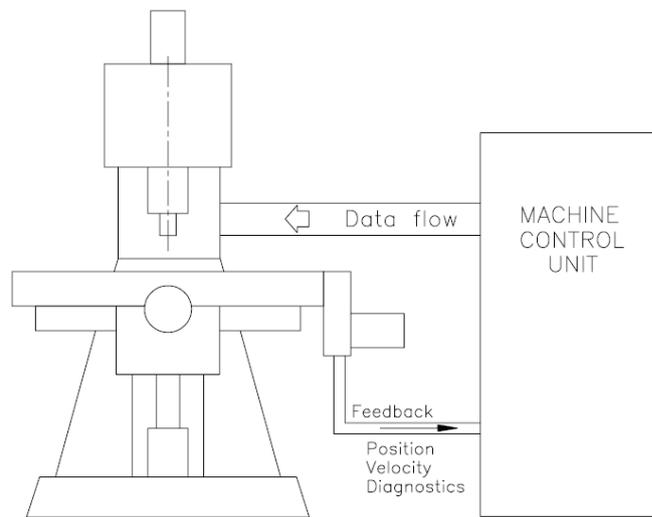
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The present day computer can be considered as a direct consequence of the progress in the field of numerical control of machine tools. A real breakthrough was achieved around 1965 when numerical control machines were fitted with minicomputers which introduced the name Computer Numerical Control. The first step in the process of implementing automation in any industry is to manufacture parts or components through automation using machines and machine tools with little human intervention. In order to meet the increasing demand to manufacture complicated components of high accuracy in large quantities, sophisticated technological equipment and machinery have been

developed. Production of these components calls for machine tools which can be set up fairly rapidly without much attention. The design and construction of Computer Numerically Controlled (CNC) machines differs greatly from that of conventional machine tools. This difference arises from the requirements of higher performance levels. The CNC machines can be operated automatically using computers. A CNC is specifically defined as “The numerical control system where a dedicated, stored program computer is used to perform some or all of the basic numerical control functions in accordance with control programs stored in read & write memory of the computer” by Electronic Industries Association (EIA).

CNC is a microprocessor based control system that accepts a set of program instructions, processes and sends output control information to a machine tool, accepts feedback information acquired from a transducer placed on the machine tool and based on the instructions and feedback, assures that proper motion, speed and operation occur.

Some of the important parts of CNC machines are Machine structure, guide ways, feed drives, spindle and Spindle bearings, measuring systems, controls, software and operator interface, gauging, tool monitoring.



**Figure 3.1 : Computer Numerical Control (CNC) Machine**

The information stored in the computer can be read by automatic means and converted into electrical signals, which operate the electrically controlled servo systems. Electrically controlled servo systems permits the slides of a machine tool to be driven simultaneously and at the appropriate feeds and direction so that complex shapes can be cut, often with a single operation and without the need to reorient the work piece. Computer Numerically Control can be applied to milling machines, Lathe machines, Grinding machines, Boring machines, Flame cutters, Drilling machines etc.

A CNC system basically consists of the following :

- (a) Central processing unit (CPU)
- (b) Servo control unit
- (c) Operator control panel
- (d) Machine control panel
- (e) Programmable logic controller
- (f) Other peripheral devices.

### **3.2.1 Central Processing Unit (CPU)**

The CPU is the heart of a CNC system. It accepts the information stored in the memory as part program. This data is decoded and transformed into specific position control and velocity signals. It also oversees the movement of the control axis or spindle and whenever this does not match with the programmed values, a corrective action is taken.

All the compensation required for machine acquires (like lead screw pitch error, tool wear out, backlashes.) are calculated by CPU depending upon the corresponding inputs made available to the system. The same will be taken care of during the generation of control signals for the axis movement. Also, some basic safety checks are built into the system through this unit and continuous necessary corrective actions will be provided by CPU unit. Whenever the situation goes beyond control of the CPU, it takes the final action of shutting down the system and in turn the machine.

### 3.2.2 Servo Control Unit

The decoded position and velocity control signals, generated by the CPU for the axis movement forms the input to the servo control unit. This unit in turn generates suitable signals as command values. The command values are converted by the servo drive units which are interfaced with the axes and the spindle motors. The servo control unit receives the position feedback signals for the actual movement of the machine tool axes from the feedback devices (like linear scales, rotary encoders, revolvers, etc.)

### 3.3.3 Operator Control Panel

The Operator Control Panel provides control panel provides the user interface to facilitate a two way communication between the user, CNC system and the machine tool. This consists of two parts are Video display unit and Keyboard.

### 3.3.4 Machine Control Panel

It is the direct interface between the operator and the NC system, enabling the operation of the machine through the CNC system. During program execution, the CNC controls the axis the motion, spindle function or tool function on a machine tool, depending upon the part program stored in the memory. Prior to the starting of the machining process, machine should first be prepared with some specific tasks like, establishing a correct reference point, loading the system memory with the required part program, loading and checking of tool offsets, zero offsets, etc.

### 3.3.5 Programmable Logic Controller (PLC)

A PLC matches the NC to the machine. PLC's were basically as replacement for hard wired relay control panels. They were basically introduced as replacement for hard wired relay panels. They developed to be re-programmed without hardware changes when requirements were altered and thus are re-usable. PLC's are now available with increased functions, more memory and larger input/output capabilities. In the CPU, all the decisions are made relative to controlling a machine or a process. The CPU receives input data, performs logical decisions based upon stored programs and drives the output connection to a computer for hierarchical control are done through CPU.

### 3.3.6 Other Peripheral Devices

These include sensor interface, provision for communication equipment, programming units, printer, tape reader interface, etc.

### 3.3.7 CNC Concept

A CNC system may be characterized in terms of three major elements: hardware, software and information.

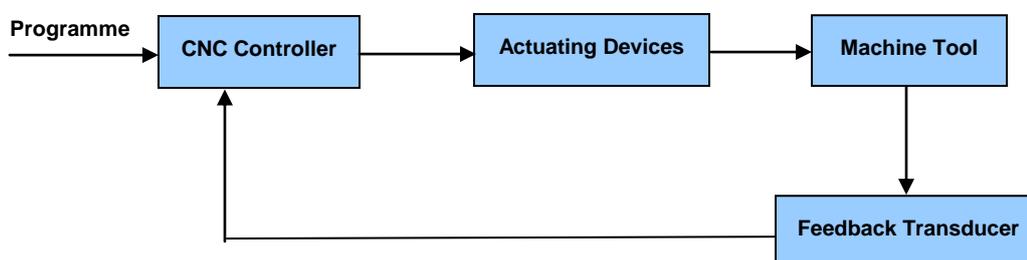


Figure 3.2 : Computer Numerical Control (CNC) System

### 3.3.8 Hardware

Hardware includes the microprocessors that effect control system functions and peripheral devices for data communication, machine tool interfacing and machine tool status monitoring.

### 3.3.9 Software

Software includes the programs that are executed by the system microprocessors and various types of software associated with CNC.

### 3.3.10 Information

Information regarding the dynamic characteristics of the machine and many other information pertaining to the process.

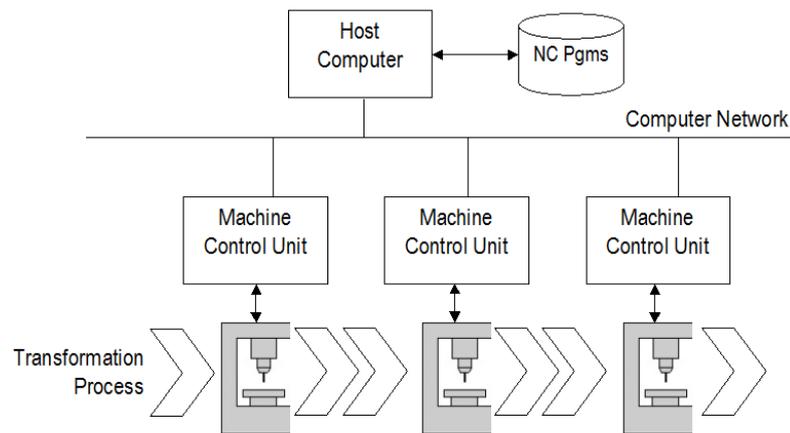
When any of these unreliable components fails, the diagnostics subsystem would automatically disconnect the faulty component from the system and activate the redundant component in place of faulty one so that newly installed component can perform its function.

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## 3.3 DIRECT NUMERICAL CONTROL (DNC) MACHINES

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Direct Numerical Control can be defined as a type of manufacturing system in which several NC or CNC machines are controlled remotely from a Host/Main frame computer or direct numerical control (DNC) – control of multiple machine tools by a single (mainframe) computer through direct connection.



**Figure 3.3 : Direct Numerical Control (DNC) Machine**

A DNC is specifically defined as “A system connecting a set of numerically controlled machines to a common memory for part program or machine program storage with provision for on-demand distribution of data to machines” by Electronic Industries Association (EIA). In DNC, several NC machines are directly controlled by a computer, eliminating substantial hardware from the individual controller of each machine tool. The part-program is downloaded to the machines directly (thus omitting the tape reader) from the computer memory. The basic DNC system requires following basic component are Main frame computer, Memory, Communication network, NC machine tool. The communication network can be done either through connecting the remotely located computer, with lengthy cables to the individual machine control directly or connecting the main frame computer with a small computer at individual operator’s station known as satellite computer. DNC system is expensive and is preferably used in large organizations. The combination of DNC/CNC makes possible to eliminate the use of programme as the input media for CNC machines. The DNC computer downloads the program directly to the CNC computer memory. This reduces the amount of communication required between the central computer and each machine tool.

### 3.3.1 Advantages of DNC

- (a) The computer can be remotely located, even a thousand miles away.
- (b) The computer can program simultaneously many NC machines.

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## 3.4 ADVANTAGES OF CNC MACHINES

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- (a) High Repeatability and Precision, e.g. Aircraft parts.
- (b) Volume of production is very high.
- (c) Complex contours/surfaces need to be machined, e.g. Turbines.
- (d) Flexibility in job change, automatic tool settings, less scrap.
- (e) Safer, higher productivity, better quality.
- (f) Less paper work, faster prototype production, reduction in lead times.
- (g) Easier to program.
- (h) Easy storage of existing programs.
- (i) Avoids human errors.
- (j) Usually generates closer tolerances than manual machines.
- (k) Program editing at the machine tool.
- (l) Control systems upgrades possible.
- (m) Option -resident CAM system at machine tool.
- (n) Tool path verification.

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## 3.5 DISADVANTAGES OF CNC MACHINES

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- (a) Costly setup, skilled operators.
- (b) Computers, programming knowledge required.
- (c) Maintenance is difficult.
- (d) Machines have to be installed in air conditioned places.

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## 3.6 PARTS SUITABLE FOR CNC MACHINES

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The following parts are usually made in practice on the CNC Machines :

- (a) Aerospace equipments.
- (b) Automobile Parts.
- (c) Complex shapes.
- (d) Electronic industry uses CNC e.g. Printed circuit board.
- (e) Electrical industry uses CNC e.g. Coil winding.
- (f) For small to medium batch quantity.
- (g) Where the set-ups are very large.
- (h) Where the tool storage is a problem.
- (i) Where much metal needs to be removed.
- (j) When the part geometry is so complex.
- (k) The operations are very complex.

- (l) For parts subjected to regularly design changes.
- (m) When the inspection is required 100%.
- (n) When lead time does not permit the conventional tooling manufacture.
- (o) When the machining time is very less as compared to down.
- (p) Where tool storage is a problem.
- (q) Where repetitive operations are required on the work.

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### **3.7 ENVIRONMENTAL CONTROL FOR CNC MACHINES**

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There are various factors, which are very much important to maintain proper environmental conditions. CNC machines are very costly and complex in design, so great care is necessary for these machines in handling as well as up keeping. For proper working of these machines, the following environmental conditions are to be maintained

- (a) Well air circulation.
- (b) Working temperature should be within control limits.
- (c) Space should not be congested but should be quite open.
- (d) Electrical power supply should be regulated.
- (e) There should be proper disposal point for scrap.
- (f) There should not be presence of noisy source near to the machine.
- (g) There should not be presence of harmful chemicals near to the machine.
- (h) Proper lighting to the system.
- (i) The machine should be protected from the moisture.
- (j) There should not be presence of vibrating source near to the machine.
- (k) Power supply should be regulated.
- (l) Floor should be cleaned free from oily and greased.
- (m) Trained person should operate the machine.
- (n) Dust free floor space and environment.
- (o) Sufficient supply of coolant required during machining.

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### **3.8 SUMMARY**

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## **3.9 ANSWERS TO SAQs**

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Refer the preceding text for all the Answers to SAQs.