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5. INTRODUCTION TO CNC MACHINES

➢ NC & CNC MACHINES

Q. Define NC Machines.

A machine in which various functions and processing of machine tools are controlled by letters and symbols.

Q. Give advantages and application of NC Machines.

• The fixtures are reduced.
• Accuracy is improved due to reduction of human error.
• These are best suited for small batch production.
• Inspection time is reduced.

Applications: Milling, Lathe, Grinding, boring and drilling machines.

Q. What are the disadvantages of the NC system?

1. High initial cost.
2. Higher maintenance cost.
3. Higher tooling cost.
4. Need for a controlled environment.
5. Higher personnel costs.

Q. What are the basic components of NC system? Or what is working principle of NC machines?

There are three components of NC systems.

• Program of instructions
• MCU- Machine control unit
• Machine tool
Program of instructions:

It is the set of directions which tell the machine tool what to do and in what sequence. The part program is written in coded form and contains all the information needed for machining the component. The part program is fed to the MCU through some input medium.

1. Punched card
2. Magnetic tape and
3. Paper tape

MCU:

It consists of the electronics and hardware that read and interpret the program of instructions and convert it into mechanical actions of the machine tool. Programme reader is a device used to read the coded instructions. Types of readers are

1. Card reader
2. Punched tape reader
3. Magnetic tape reader
**Machine tool:**

In a numerically controlled machine all the movements of the tool and the machine table are done automatically with the help of electric motors. The functions like tool change, machine ON/OFF and coolant ON/OFF are controlled through part program.

**Q. Define CNC.**

*CNC or Computer Numerical Control is an NC system using a dedicated microcomputer as the machine control unit.*

The presence of a microprocessor, RAM, ROM, input and output devices have raised the level of automation in NC systems.

**ADVANTAGES AND DISADVANTAGES OF CNC MACHINES**

**Advantages:**

- Reduced lead time.
- Elimination of operator’s errors.
- Lower labour cost.
- Flexibility in changes of component design.
- Reduced inspection.

**Disadvantages:**

- Higher investment cost
- Higher maintenance cost.
- Higher personnel costs.
- Planned support facility is required.
WORKING PRINCIPLE OF CNC MACHINES

A CNC machine also has a tape reader or any other input media for entry of the part program. CNC uses the part program in a different manner though there is similarity between NC and CNC. In CNC, entire program is first fed to the inbuilt computer memory. Once the program is stored, the machine cycle is then executed by the program. Software with control algorithms converts the part program instructions into actions by the machine tool.

This is done by generating pulses for each axis from the controller. Each pulse produces one small unit of motion (SUM). The slide travel is thus decided by the number of pulses. In a closed loop system, the pulses are fed to a reference. The
feedback device also sends the signal to the reference. These two signals are compared and necessary action is controlled.

DIFFERENCE BETWEEN CONVENTIONAL MACHINES & CNCS

1. Basically conventional m/c has 2 axes, known as X & Y axis. There is also a Z axis along which only the bed moves vertically. The spindle along with the tool does not move as it is fixed with the m/c body. But in case of CNC m/c, there are minimum 3 axes. Spindle moves parallel to Z axis.

2. In case of conventional m/c the axis moves on the guide ways, but there is direct contact of metal surfaces so the lubrication effect is so less and wear & tear is high. But in case of CNC m/c there is a layer of PTFE (Poly Tetra-Fluro-ethylene) or turcide (50% bronze added with PTFE) is fastened on the guideways. After a certain time if this layer is not affected, then a new layer is replaced with the old one. Thus the downtime of the m/c is less than the conventional m/c.

3. Lead screw is responsible for axis movement in conventional m/c, where the contact surface area of screw & nut is so high, which causes the high frictional resistance, so the accuracy of the m/c is low.

But in CNC m/c uses the ballscrew where highly polished chromium coated ball is placed between nut & screw, so the contact surface between the nut & screw is point & the contact surface area is low which causes low frictional resistance & high machine accuracy.

4. Most of the machining operation in conventional m/c is executed by manual operation (except some auto mode). But in case of CNC m/c the
movements (AXIS movement, TOOL MAGAZINE movement, ATC arm movement, SPINDLE movement, TURRET movement, CHUCK HEAD movement, PALLET movement, ATC DOOR movement) are hydraulically or pneumatically operated & those movements are restricted in limits by proximity switch. Those hydraulic or pneumatic operations are computerised programming controlled.

Q. What is DNC?

Direct numerical control (DNC) is defined as a system which integrates a number of machines by controlling it through a central computer by direct connection.

The central computer is designed to provide instructions to each machine tool on demand. The central computer also receives data back from the machines. Thus, there is a two way information exchange between the central computer and each of the machine tool.

Q. what are the functions of DNC System? What are its types?

1. To use the central computer for storing and editing programs for all machine tools connected to it.

2. To transfer the stored programs to the connected machines on demand.

3. To post process part programs written in higher level languages like APT.

4. To integrate CAD with CAM by having a common database.

5. To provide a link between a central computer and various plant computers connected through modems and networks even though the plants may be placed several kilometers away from each other.
INTRODUCTION TO CNC MACHINES

Types of DNC system

1. Behind the Tape Reader (BTR) system

2. Specialised MCU

Q. Give advantages and disadvantages of DNC system.

Advantages:

1. DNC eliminates the use of the tape reader, which is certainly the weakest component in the NC system.

2. Time sharing by the central control makes it possible to keep a close control over the complete machine shop.

3. The huge memory of DNC allows it to store a large amount of part programs for subsequent use. It also receives the memories of NC control unit.

4. Presence of a central bulk memory allows the same program to be run on different machines at the same time without duplicating it at individual places.
Disadvantages:

1. DNC uses a central control and in an event of computer failure, the complete activities of the machine shop would come to a standstill.

2. DNC is expensive and its use is practical in areas where high automation is required.

➢ CLASSIFICATION OF THE CNC MACHINES

CNC are classified in two ways,

1. According to number of axis

2. According to CNC control system

1. According to number of axis:

Generally, there are three major axes on CNC machines. In the programs these axes are denoted as X, Y and Z. Each axis moves in right angles to each other. U, V and W are parallel to X, Y and Z respectively. A, B and C are three rotating axes of the major axes.

a. 2 Axis machine: In this machine only two main (major) axes are used for tool movement. Example- Turning centres and Chucker.

b. 3 Axis machine: In this machine three major axes are used for tool movement. Example- VMC.
c. 4 Axis machine: for the tool movement, three major and either rotating or parallel axis are used. Example- VMC.

Now days, in industries 5 Axis, 6 Axis and 7 Axis machines are also used.

2. According to CNC control system: (Control on feed)

Tool on CNC machines moves either in rapid or in feed. It moves in feed during cutting operation otherwise it moves rapidly. Machine is classified according to feed given to tool in three ways:

a. Point To Point control system:

In this control system, tool moves in feed in only one direction (only in one axis) while tool moves rapidly in another directions (axes). Example- Drilling, reaming, tapping, punch press and jig boring.

b. Straight cut control:

In this system, tool can move in feed in any two (directions) axes and it can move rapidly in all directions but tool follows straight path with the feed in one direction at a time. Example- Milling, step turning, slot cutting, key way cutting and groove cutting.
c. Contouring control system:

In this system, all axes can be moved in feed and rapid mode. Due to this any critical and complex surfaces can be cut easily on such machines. Example- Inclined or curvature slot cutting and helical groove cutting.

➢ TYPE OF TOOLS USED ON TURNING CENTER AND VMC.

Tools are classified On the Basis of Cutting Tool Material

(a) High speed steel (HSS).

(b) High carbon tool steel (HCS).
(c) Cast alloy.
(d) Cemented carbide.
(e) Ceramics.
(f) Boron Nitride.
(g) Diamond.

a) High Speed Steel: The H.S.S. is carbon steel to which alloying elements like tungsten, chromium, Vanadium, cobalt and molybdenum to be added to increase their hardness and wear resistance.

b) High Carbon Tool Steel: High carbon tool steel is suitable for low cutting speeds and low temperatures. The hardness of this tool is determined by the carbon contents.

c) Cast Alloy: This is a non ferrous alloy and gives high machining performance than that of H.S.Steel. Its hardness and toughness are high at higher temperatures.

d) Cemented Carbides: It contains 5% carbon, 13% cobalt and 81%tungsten. This tool is widely used in modern costly machines as tip tools. The tool setting time is reduced.

e) Ceramics: It can be used for higher cutting speed, superior surface finish and great machining flexibility. The Aluminium oxides, boron carbides, silicon carbide, titanium borides and titanium carbides are known as ceramics.

f) Boron Nitride
(a) High wear resistance.
(b) Used for machining hardened steel and high temperature alloys.

g) Diamond
(a) Low friction and high wear resistance.
(b) Good cutting edge.

(c) Single crystal diamond is used to machine copper to a high surface finish.
MILLING CUTTER MAGAZINE

Tools are also classified On the Basis of Cutting Tool Construction

(a) Solid tools.
(b) Brazed tools.
(c) Inserted bit tools.

**Solid Tools:** Solid tools are usually made of High speed steel or High carbon steel. These tools are used on high speeds with sufficient quantity of cutting fluid to get good surface finish and longer tool life.

**Brazed Tools:** A forged shank of high strength steel with belt of high speed steel, tungsten carbide stellite brazed to the shank on the cutting edge.

**Inserted Bit Tools:** The tools with indexible inserts of harder and special grade carbide or ceramic materials. A wear resistant layer of Titanium nitride of Titanium carbide is coated on the insert it reduces the cost of tool. Inserts can be easily removed from the tool holder. So tool changing time and cost of machining are less.
COORDINATE SYSTEMS IS USED IN CNC MACHINES

The part program on CNC machine depends upon a tool path which is prepared according to operations on workpiece (job). It is necessary to locate a work zero position on the job to prepare a tool path. With reference to work zero position the coordinates of all points on a tool path are determined.

To determine the coordinates, graphical method is used. On the graph, the point of intersection of two axes termed as an original point (coordinates of original point are zero). All axes of job intersect at work zero point and considering this point as an original point, coordinates of remaining points are determined. Use of proper signs play significant role for determining these coordinates. To determine the coordinates, two systems are used.

- Absolute Coordinates system
- Incremental Coordinate System
**Absolute Coordinates system:**

In absolute programming, all coordinate values are relative to a fixed origin of the coordinate system. Axis movement in the positive direction does not require inclusion of the sign; while negative movements do require signs.

**Incremental Coordinate System:**

In incremental systems, every measurement refers to a previously dimensioned position (point-to-point). Incremental dimensions are the distances between two adjacent points.

The coordinate notations for the points on the drawing (in absolute and incremental systems) appear in the chart as follows:
<table>
<thead>
<tr>
<th>POINTS</th>
<th>ABSOLUTE (G90)</th>
<th>INCREMENTAL (G91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>X0 Y0</td>
<td>X0 Y0</td>
</tr>
<tr>
<td>P2</td>
<td>X0 Y4</td>
<td>X0 Y4</td>
</tr>
<tr>
<td>P3</td>
<td>X2 Y4</td>
<td>X2 Y0</td>
</tr>
<tr>
<td>P4</td>
<td>X2 Y5</td>
<td>X0 Y1</td>
</tr>
<tr>
<td>P5</td>
<td>X4 Y6</td>
<td>X2 Y1</td>
</tr>
<tr>
<td>P6</td>
<td>X4 Y7</td>
<td>X0 Y1</td>
</tr>
<tr>
<td>P7</td>
<td>X6 Y6</td>
<td>X2 Y-1</td>
</tr>
<tr>
<td>P8</td>
<td>X8 Y8</td>
<td>X2 Y2</td>
</tr>
<tr>
<td>P9</td>
<td>X8 Y4</td>
<td>X0 Y-4</td>
</tr>
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<td>P10</td>
<td>X5 Y4</td>
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</tr>
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<td>P11</td>
<td>X5 Y3</td>
<td>X0 Y-1</td>
</tr>
<tr>
<td>P12</td>
<td>X7 Y3</td>
<td>X2 Y0</td>
</tr>
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<td>X7 Y2</td>
<td>X0 Y-1</td>
</tr>
<tr>
<td>P14</td>
<td>X3 Y0</td>
<td>X-4 Y-2</td>
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