

## NC Part Programming:

- In machine tool applications, the task of programming the system is called NC part programming because the program is prepared for a given part.
- Part programming requires the programmer to define the points, lines, and surfaces of w.p. in the axis system, and to control the movement of the cutting tool relative to these defined part features.
- Several part programming techniques are available, the most important of which are *(1) manual part programming, (2) computer-assisted part programming, (3) CAD/CAM-assisted part programming, and (4) manual data input.*

### **(1) Manual Part Programming:**

- For simple point-to-point machining jobs, such as drilling operations, manual programming is often the easiest and most economical method.
- It uses basic numerical data and special alphanumeric codes to define the steps in the process.
- For example, to perform a drilling operation, a command of the following type is entered:

**n010x70.0 y85.5 f175 s500**

**n:** (n010) is a sequence number for the statement.

**x and y:** indicate the x and y coordinate positions.

**f and s:** specify the feed rate and spindle speed to be used in the drilling operation.

x = 70.0 mm, y = 85.5 mm, f = 175mm/min, s = 500 rev/min

- The complete NC part program consists of a sequence of statements similar to the above command.

### **(2) Computer-Assisted Part Programming:**

- It involves the use of a high-level programming language.
- The first part programming language was APT (Automatically Programmed Tooling), developed as an extension of the original NC machine tool research and first used in production around 1960.
- In APT, the programming task is divided into two steps: **(1) definition of part geometry** and **(2) specification of tool path and operation sequence.**
- In step 1, the programmer defines the geometry of w.p. by means of points, lines, planes, circles, and cylinders.

- They are defined using APT geometry statements, such as:

P1 = POINT/25.0, 150.0

L1 = LINE/P1, P2

P1: is a point defined in the x-y plane located at x = 25 mm and y = 150 mm.

L1: is a line that goes through points P1 and P2.

- Similar statements can be used to define circles, cylinders, and other geometry elements.

- Specification of the tool path is accomplished with APT motion statements.

A typical statement for point-to-point operation is:

***GOTO / P1** : this directs the tool to move from its current location to a position defined by P1 (P1 defined by a previous APT).*

- To present the continuous path command for example:

***GORGT = L3, PAST, L4** : this directs the tool to go right (GORGT) along line L3 until it is positioned just past line L4 (of course, L4 must be a line that intersects L3).*

- Additional APT statements are used to define operating parameters such as feed rates, spindle speeds, tool sizes, and tolerances.
- When completed, the part programmer enters the APT program into the computer, to generate low-level statements (similar to statements prepared in manual part programming).

### **(3) CAD/CAM-Assisted Part Programming:**

- The use of CAD/CAM takes computer assisted part programming a step further by using a computer graphics system (CAD/CAM system) to interact with the programmer as the part program is being prepared.
- To avoid the programming errors (during computer processing) in APT, a CAD/CAM system is used, where the programmer receives immediate visual verification (for each statement entered) to determine whether the statement is correct.
- When part geometry is entered by the programmer, the element is graphically displayed on the monitor.
- When the tool path is constructed, the programmer can see exactly how the motion commands will move the tool relative to the part.
- Errors can be corrected immediately rather than after the entire program has been written.

- **First:** The design of the product and its components may have been accomplished on a CAD/CAM system in NC part programming.
- The design database, including the geometric definition of each part, can be retrieved by the NC programmer to use as the starting geometry for part programming.
- This retrieval saves valuable time compared to reconstructing the part from scratch using the APT geometry statements.
- **Second:** special software routines are available in CAD/CAM-assisted part programming to automate portions of the tool path generation, such as profile milling around the outside periphery of a part, milling a pocket into the surface of a part, surface contouring, and certain point-to-point operations.

#### **(4) Manual Data Input (MDI):**

- It is a method in which a machine operator enters the part program in the factory.
- The method involves use of a CRT display with graphics capability at the machine tool controls.
- Because part programming is simplified and does not require a special staff of NC part programmers, MDI is a way for small machine shops to economically implement numerical control into their operations.

### **Applications of Numerical Control:**

- Machining is an important application area for NC, but other applications can be applied as well.
- We divide the applications into two categories: (1) machine tool applications, and (2) nonmachine tool applications.
- It should be noted that the applications are not all identified by the name NC in their respective industries.
- In the machine tool category, NC is widely used for machining operations such as turning, drilling, and milling.
- Using of NC in these processes has motivated the development of highly automated machine tools called machining centers, (change own cutting tools to perform a variety of machining operations under NC).
- In addition to machining, other numerically controlled machine tools include (1) grinding machines (2) sheet metal pressworking machines (3) tube-bending machines and (4) thermal cutting processes.
- In the nonmachine tool category, NC applications include (1) tape-laying machines and filament-winding machines for composites (2) welding machines, both arc welding and resistance welding (3) component-insertion machines in

electronics assembly (4) drafting machines and (5) coordinate measuring machines for inspection.

- Benefits of NC relative to manually operated equipment in these applications include (1) reduced nonproductive time, (shorter cycle times), (2) lower manufacturing lead times, (3) simpler fixturing, (4) greater manufacturing flexibility, (5) improved accuracy, and (6) reduced human error.