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Module 7 – Introduction to CNC Sheet Metal Manufacturing

Unit 4 – CNC Drawings & Documentation

Duration – 14 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- Convert a conventional drawing into a coordinate drawing and tabulate coordinate values
- Analyse programme information for a simple part programme

Key Learning Points:

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Training Resources:

- Printouts of simple part programmes
- Conventional component drawings and coordinate drawings
- Coordinate sheets
- Programme sheets
- G code listings
- Pressbrake data

Key Learning Points Code:

- M = Maths
- D = Drawing
- RK = Related Knowledge
- S = Science
- P = Personal Skills
- Sk = Skill
- H = Hazards
Machine Axis Configuration

Controlled axes on CNC machine tools are identified according to the British Standards Institution; the standard identifies 25 CNC related machines. The basis of axis classification is the three dimensional CARTESIAN coordinates system. This is the system employed for graphical plotting, i.e. X, Y and Z. Direction of movement being either plus + or minus -.

CNC Flame Cutting

Figure 1 - CNC Flame Cutting
CNC Press Brake Datum

As with the punch machine the X and Y axis must be Datumised or Referenced. The datum position is shown below.

Figure 2 - Datum Position

CNC Punch

Figure 3 - CNC Punch
Workpiece and Machine Datum

The above are just a few considerations, there are many more. Because of this the Management will have some form of CHECK LIST which again may be done using a computer or by conventional means.

One of the most important features to consider with any component design is the DATUM. Since not only have the CNC machines a referred or DATUM position but also drawings must be considered relative to the DATUM and dimensioning. The reason for this is that ultimately a program will have to be made from a drawing and if it has been dimensioned correctly then programming becomes a little easier.

The meaning of the Datum Point is a point or edge where all dimensions or commands are taken.

Positioning

NC systems perform many functions; the most important controlled operation is static or dynamic positioning of the tool with the use of a system of coordinates that is general enough to define any geometric motion.

The right handed Cartesian coordinate system provides a simple method for the definition of any point in three dimensional space. While all NC machines make use of a coordinate system, some require only two axis (X and Y) motion and the others require 3-D linear and angular axes.

Machine Axes

The primary axes of a machine are designated as X, Y, Z and can have positive or negative values.

The secondary axes of a machine are designated as U, V, and W being 3 extra planes used with incremental dimensioning.
Cartesian Coordinate System

The Cartesian or rectangular coordinates system was discovered by the French mathematician and philosopher Rene Descartes. With this system, any specific point can be described in mathematical terms from any other point along three perpendicular axes. This concept fits machine tools perfectly, since there construction is generally based on three axes of motion (X, Y and Z) plus an axis of rotation. Numerical control systems rely heavily on the use of rectangular coordinates because the programmer can locate every point on the job precisely.

For locating points on a workpiece, two straight intersecting lines, one vertical and one horizontal are used. These lines must be at right angles to each other and the point where they cross is called the origin datum or zero point.

![Figure 4 - Intersection Lines Form Right angles and Establish the Zero (0) Point](image)

The three dimensional coordinate planes are shown. The X- and Y-planes (axes) are horizontal and represent horizontal machine table motions. The Z-plane (axis) represents vertical tool motion.

![Figure 5 - Three-Dimensional Coordinate Planes (Axes) used in Numerical Control Work](image)
Coordinate Systems

There are three types of coordinate systems that can be employed by the MCU to position a tool or cutter. Each system has its own application and with some machines the systems can be used independently or mixed. Obviously if a machine can be used with all three systems it gives more versatility to the designer, draughtsman and programmer.

1. **ABSOLUTE** method of dimensioning is where all the dimensions are measured from the Datum. Therefore dimensions will be X+, Y+, Z+.

![Figure 6 - Absolute Coordinate System](image)

Figure 6 - Absolute Coordinate System
2. **INCREMENTAL** methods of dimensioning is where the dimensions are measured from the last position described, again dimensions will be X+/−, Y+/− and Z+/−.

![Incremental Coordinate System](image)

**Figure 7 - Incremental Coordinate system**

3. **POLAR** coordinates describe the position of a feature by a length, measured from a specific point and an angle (measured in degrees) from a specified Datum.

![Polar Coordinate System](image)

**Figure 8 - Polar Coordinate System**
Word Addressed System (ISO Letter Address)

The word addressed system is the method generally used today for the control of a wide variety of machines and other equipment such as plotters. A word consists of a letter followed by a number. The letter is referred to as the address and between the letter and the number there may be an algebraic sign; normally only the negative (minus) sign has to be used.

An operation that is defined in a block can contain a single word or a number of words. If there is to be no change in a word it is normally not necessary to enter it in the succeeding blocks. When the function remains active and it is not necessary to repeat words, the words are termed MODAL; when it is necessary to repeat words they are termed NON-MODAL.

Example of a block of information:

N01G71X100Y100I20A45H6T3F20

Structure Programs

A part program contains all the information for the machining of a component which is input to the control unit. The control unit provides the control signals at the correct time and in the correct sequence to the various drive units to the machine.

The input information required is in the series of blocks; one operation requires one block. Within each block there may be different types of data.
Program Structure

Every program consists of three sections:

- Program Start
- Operating Program
- Program End

Program Start

For example on the Trumpf TC 260 every program must start with the block end sign (LF = line feed). All characters before the first block end sign are skipped by the control. Thus the control identifies
- the beginning of the program;
- the program code.

In the second block the program number (max. 9 digits) can be put in with the desired text.

Operating Program

Without program-technical commands the program blocks are operated after one another. A modification of the program sequence is possible using
- subroutine call-ups;
- repeat commands;
- jump commands;
- optional block suppression.

Program End

The end of the program is marked by the additional functions M02 or M30. M02 and M30 must be programmed individually in the last block. Thus the machine is reset to the default setting. At the end of a subroutine M02 or M30 effect only a return to the actual program.

There are three basic types of input information in a part program for control of the machine:

- Information on desired work/tool relationship (position, direction and amount of movement)
- Information on rate of change of work/tool relationship (feeds and speeds)
- Information on auxiliary functions (mode of operation, selection of metric or imperial units, tool selection, use of cutting fluids, work or tool loading etc.)
The command data contained in an NC block is obtained using methods that range from referring to simple tabular information to performing rather complex mathematical calculations.

Non-dimension values take on two forms: (1) functions that are selected based on predefined tabular standards and (2) functions that must be computed based on the operation to be performed. The first group consists of four functions: sequence number and preparatory, miscellaneous and tool functions.

### Sequence Numbers

The sequence number (N code) is used to identify each block within an NC program and provides a means by which NC commands may be rapidly located.

### Preparatory Functions

The preparatory function (G code) is used as a communication device to prepare the MCU. It changes the mode of operation of the MCU. The G word indicates that a given control function, such as punch a row of holes (G71), is to be requested. Other examples would be Motion Delay and Dimensional Data.

### Miscellaneous Functions

Miscellaneous functions (M code) are used to designate a particular mode of operation for a numerically controlled machine tool. Most miscellaneous functions deal with opposing machine conditions, for example gas on, gas off.

### The Tool Function

The tool function (T code) is used as a means of addressing the new tool. Numerical control machines often have an automatic tool change apparatus for supplying the tool (i.e. Turret Magazine); each tool may be individually numbered or may be identified by the number of its location in the tool storage system, designated using the T word.
Self Assessment

Questions on Background Notes – Module 7.Unit 4

1. Name the Primary and Secondary axes of a machine.

2. How would you locate a point on a workpiece using the Cartesian system?
3. How would you convert a conventional drawing to a coordinate drawing?

4. List three of the procedures involved in determining the bending sequence.
Answers to Questions 1-4. Module 7.Unit 4

1.

The primary axes of a machine are X,Y,Z and can have a positive or negative value.

The secondary axes are called U,V and W being three extra planes used with incremental dimensioning.

2.

For locating points on a workpiece, two straight intersecting lines one vertical and one horizontal are used. These lines must be at right angles to each other and the point where they cross is called the origin datum or zero point.
3.

**Convert a conventional drawing to a co-ordinate drawing:**

a. Read the component drawing to identify material type and thickness.

b. Identify equipment needed (punch and press).

c. Make cut co-ordinate drawing (flat pattern).

d. Identify punches required (tool list).

e. Identify G. codes required.

f. Write the programme.
4.

**Bending Sequence:**

The procedure for determining the bending sequence involves investigation of the following:

a. The bending shape required.

b. The first and final stage of bending.

c. Important dimensions of the product.

d. Efficiency of the work handling.

e. Relationship between bending angle and backgauge position.

f. Examination of pre-bending.
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