

## Study on computer numerical control (CNC) machines

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### Abstract

The main objective of this paper is to “Study on Computer Numerical Control (CNC) machines for fabrication of rollers. This paper also includes various processes like facing, turning, parting, drilling, boring and knurling to improve production in order to decrease the production time and also to increase the efficiency in conventional lathe and CNC machines by writing the program on STC-25 CNC lathe.

**Keywords:** Study, Computer Numerical Control (CNC) Machines, various operations

### 1. Introduction

1. The design is loaded into the computer which is attached to the CNC machine. The computer changes the design into a special code (numerical) that controls the way the CNC cuts and shapes the material.
2. The material to be shaped is taped on to a block with double sided tape. This must be done carefully so that it does not come off the block during machining.
3. The block is then placed in the vice, inside the CNC. It must be tightened up carefully. If it is not secure when the machine starts to cut the material it can come away from the vice. When the machine starts working, the vice moves up, down, right and left according to the design.
4. The guard is placed in position. It protects the machine operator in case the material is pulled out of the vice by the power of the cutter. For safety reasons, if the guard is not in position the motor will not start.
5. The CNC is turned on and the shape is cut from the material. When the cutter has stopped the shaped material can be removed from the vice. Total time - for simple designs - 15 minutes.

### 1.1 CNC Machine-Input, Process, Output

A CNC production facility needs three pieces of equipment.

#### A Computer

The computer is used to draw the design. However, the design is only a picture and the CNC machine cannot use this to manufacture the product. The computer software must also convert the drawing into numbers (coordinates) that the CNC machine can use when it starts to cut and shape the material.

#### An Interface

A computer cannot be directly connected to a CNC machine. The computer is connected to an interface. This converts the signals from the computer to a form that the CNC machine understands. The signals are in the form of digital signals when they are sent to the CNC machine.

#### CNC (Computer Numerical Control) Machine

The signals from the interface control the motors on the CNC machine. The signals determine the way the vice moves. The vice moves in three directions X, Y and Z. (Horizontally, vertically and depth). The signals also control the speed of the cutting tool.

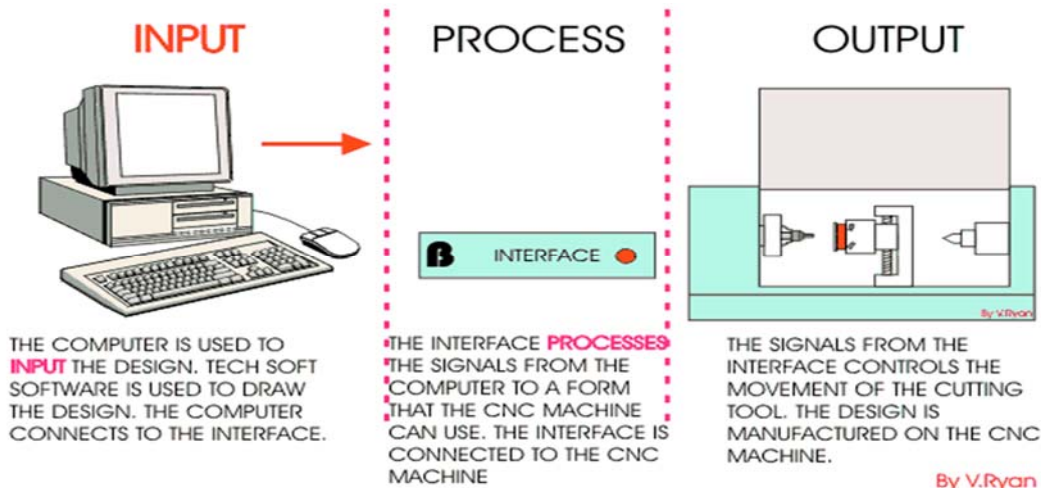


Fig 1

### 1.2 CNC Control Panel

A CNC machine is normally controlled by a computer and software. However, most CNC machines have a range of controls for manual use. It is rare for a CNC machine to be

used manually as simple operations are best carried out on cheap/basic/manual machines. When a CNC machine is used manually it is been used well below its capability and specification.

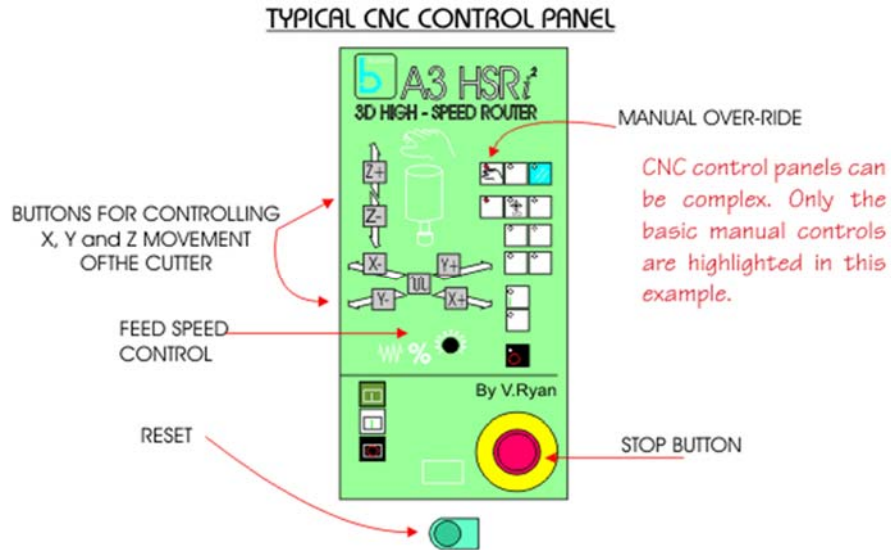


Fig 2

- **Reset Button:** The most important control button is usually the reset button. When the CNC machine is turned on, the reset button is pressed by the machine operator. This ‘zeros’ the cutter, moving the cutter to coordinates 0, 0, 0 on the X, Y and Z axis. In simple terms, the reset button moves the cutter to the corner of the machine, above the work table. If the reset button is not pressed, it is possible that the CNC machine will start cutting the material in the wrong place or even miss cutting the material and plunge into the work table.
- **Manual Control:** The cutter can be controlled manually although this is rarely needed. The ‘X’ and ‘Y’ buttons control the movement of the cutter along the horizontal surfaces. The ‘Z’ buttons control depth and up / down movement.
- **Stop Button:** Most control panels have stop buttons. When pressed these stop the machine very quickly.
- **Speed and Feed:** On some CNC machines it is possible to manually vary the speed and feed of the cutter.

### 2. Setting up the cutting tool to the correct length

One of the few operations that the machine operator carries out is to change the cutting tool. Each CNC machine has a range of cutting tools. Straight cutters chamfer V-groove and radius cutters are some examples. If a detailed design is being manufactured, it may be necessary to change the cutting tool at least once during the manufacturing process. It is very important that all the cutters are set up to exactly to the same length in the collets. If this is not done the material being machined will be machined at incorrect depths. A special depth gauge is used to accurately set up the cutting tools. (See diagram below). This ‘rule’ applies to all CNC machines although different techniques may be used depending on the type of the CNC machine.

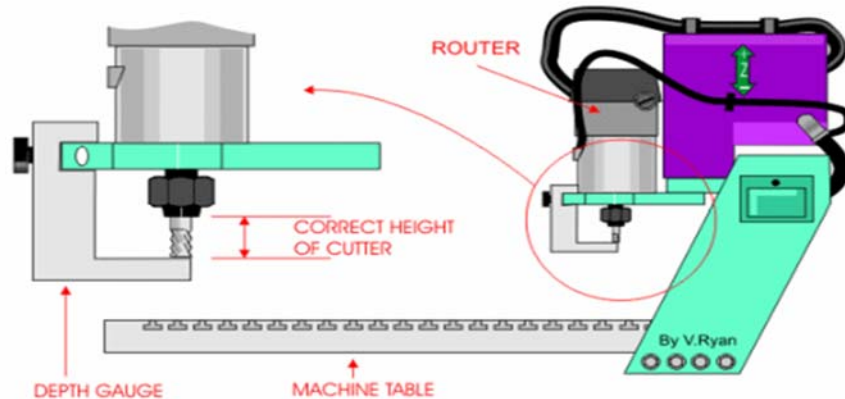


Fig 3

A pair of spanners is used to loosen the collet and locking nut. The cutting tool can then be removed and the new tool put in

position. Once the depth gauge has been used to check the distance from the end of the cutting tool to the collet, the

spanners are used again to tighten the collet and locking nut.

## 2.1 CNC Machines and Safety

CNC machines are very safe to use as they are designed to be

as safe as possible. One of the main advantages of CNC machines is that they are much safer than manually operated machines. The animation below shows a Boxford A3 HSRi<sup>2</sup> CNC Router with many of its safety features labeled.

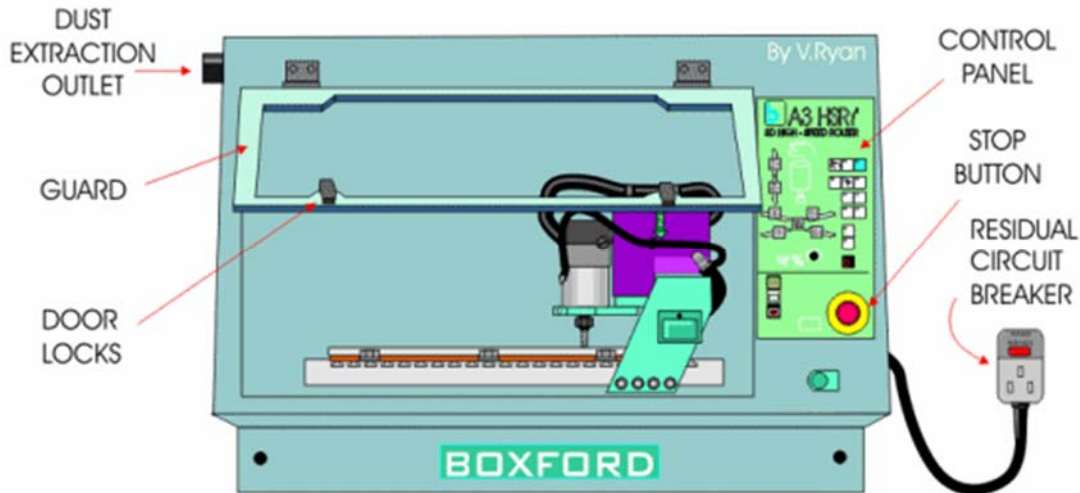


Fig 4

1. Most modern CNC machines are designed so that the cutting tool will not start unless the guard is in position. Also, the best CNC machines automatically lock the guard in position whilst the cutter is shaping material. The guard can only be opened if the cutter has stopped.
2. It is essential that pupils / students / machine operators receive 'quality' instruction before attempting to use any CNC equipment.
3. CNC routers, used for shaping materials such as woods and plastics, have built in extraction. Dust can be very dangerous if inhaled and can also cause eye irritation. The CNC Router shown above has an outlet for an extraction unit. As the router is fully enclosed, dust cannot escape into the atmosphere. If an extraction unit is attached the dust is removed automatically. Most manually operated machine routers have very limited extraction systems which leave some dust in the air.
4. The CNC router above has a single phase electrical supply. Older machines such as manually operated milling machines and centre lathes have three phase supplies. A single phase electrical supply can be 'plugged' into any available socket. The electrical supply for the machine comes through a residual circuit breaker (RCB). If an electrical fault develops the RCB will cut off electrical power immediately.
5. Single phase CNC machines can be moved more easily because they are simply unplugged and relocated. Three phase machines are specially wired by an electrician into the electrical supply and cannot be unplugged.
6. Most CNC machines work behind a guard or even a closed, transparent safety door. This means that the operated cannot be hurt by 'flying' pieces of sharp/hot material.
7. Commonsense applies to the use of all machines including CNC machines. Basic safety training regarding working in a workshop and with other machines applies to CNC machines as well.

## 3. Programmable Functions

The programmer must also know what functions of the CNC machine are programmable (as well as the commands related to programmable functions). With low cost CNC equipment, often times many machine functions must be manually activated. With some CNC milling machines, for example, about the only programmable function is axis motion. Just about everything else may have to be activated by the operator. With this type of machine, the spindle speed and direction, coolant and tool changes may have to be activated manually by the operator.

With full blown CNC equipment, on the other hand, almost everything is programmable and the operator may only be required to load and remove work pieces. Once the cycle is activated, the operator may be freed to do other company functions.

Reference the machine tool builder's manual to find out what functions of your machine are programmable. To give you some examples of how many programmable functions are handled, here is a list a few of the most common programmable functions along with their related programming words.

### Spindle control

An "S" word is used to specify the spindle speed (in RPM for machining centers). An M03 is used to turn the spindle on in a clockwise (forward) manner. M04 turns the spindle on in a counter clockwise manner. M05 turns the spindle off. Note that turning centers also have a feature called constant surface speed which allows spindle speed to also be specified in surface feet per minute (or meters per minute).

### Automatic tool changer (machining center)

A "T" word is used to tell the machine which tool station is to be placed in the spindle. On most machines, an M06 tells the machine to actually make the tool change. Tool change (on turning centers) A four digit "T" word is used to command tool

changes on most turning centers. The first two digits of the T word specify the turret station number and the second two digits specify the offset number to be used with the tool. T0101, for example specifies tool station number one with offset number one.

### Coolant control

M08 is used to turn on flood coolant. If available M07 is used to turn on mist coolant. M09 turns off the coolant.

### Automatic pallet changer

An M60 command is commonly used to make pallet changes.

### Forms of compensation

All types of CNC machine tools require some form/s of compensation. Though applied for different reasons on different machine types, all forms of compensation allow the CNC user to allow for unpredictable conditions related to tooling as the program is developed. Before discussing how compensation applies to CNC usage, let's look at compensation in general terms.

Compensation is used in many facets of everyday life. The airplane pilot must compensate for wind velocity and direction as a heading is set. The race car driver must compensate for weather and track conditions as a turn is negotiated. A bowler must compensate for the spin of the bowling ball as the ball rolls down the alley. A marksman firing a rifle must compensate for the distance to the target. The marksman analogy is amazingly similar to what happens with many forms of compensation on CNC equipment.

### Offsets

All forms of compensation work with offsets. You can think of CNC offsets as like memories on an electronic calculator. If your calculator has memories, you know you can store a constant value into each memory for use during a calculation. This keeps you from having to enter the number over and over again with redundant calculations.

Like the memories of an electronic calculator, offsets in the CNC control are storage locations into which numerical values can be placed. Just as the value within the memory of a calculator has no meaning until referenced by its user within a calculation, neither does the value within an offset of the CNC control have any meaning until it is referenced by a CNC program.

From the marksman analogy, you can think of the values stored in CNC offsets as like the amount of adjustment required on the sight of the rifle necessary to compensate for the distance to the target. Keep in mind that the rifle only needed adjustment for one purpose, to adjust for the distance to the target. With most CNC machine tools, there is a need for at least one offset per tool.

## 4. CNC Programming

### 1. Turning

Tool Holder: PDJNL 25\*25

Insert: DNMG 150604

N5 G54;

N10 M42;

N20 G95 S300 M4;

N25 LIMS=600;

N30 T01 D1 M8;

N35G00 X80 Z0;

N40 X70;

N45 G01 Z-75 F0.2;

N50 G00 X71 Z0;

N55 X60;

N60 G01 Z-50 R0.2;

N65 X70;

N70 G00 X200 Z200;

N75 M30;

### 2. Step Turning

N5 G54;

N10 M42;

N15 G95 S300 M0.4;

N20 T01 D1 M8;

N25 G00 X30 Z0;

N30 G00 X40 Z0;

N35 CYCLE95;

CYCLE95 ("STEP TURN", 5, 0.1, 0.1 . . .) X40

N40 G00 X200 Z200 M17;

N45 M30;

STEP TURN: (SUB PROGRAM)

N05 G01 X0 Z0 F0.2;

N10 G01 X20 Z-10;

N15 G01 X20 Z-30;

N20 G01 X30 Z-30;

N25 G01 X30 Z-45;

N30 G01 X40 Z-45;

N35 G01 M17;

### 3. Taper Turning

N5 G54;

N10 M42;

N15 G95 S300 M.4;

N20 T01 D1 M8;

N25 G00 X01 Z0;

N30 G01 X80 Z-45 F0.2;

N35G00 X81 Z0;

N40 G01 X60 Z-30 F0.2;

N45 G00 X81 Z0;

N50 X50;

N55 G01 Z-68 F0.2;

N60 X60 Z-15;

N65 G00 X51 Z0;

N70 X40;

N75 G01 X50 Z-6.5 F0.2;

N80 G00 X200 Z200;

N85 M30;

### 5. Conclusion

In the study of computer numerical control machines the production improvement can be done more effectively and efficiently.

The CNC programming is a way to operate CNC machine. CNC Lathe machine usage gives many benefits of increased productivity and accuracy and time management but the only drawback is its cost. This could not be employed for all small jobs and is preferable to use in large amount of production and complicated shapes.

CNC Lathe machines are economical only for industrial purposes in large scale production and is not suitable for small scale industries because of its high initial cost.

## 6. References

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