PROJECT REPORT ON

CNC MACHINE USING ARDUINO AND GRBL SHIELD

A THESIS SUBMITTED IN THE PARTIAL FULFILMENT OF THE

REQUIREMENTS FOR THE DEGREE OF BACHELOR OF TECHNOLOGY

SUBMITTED TO

VIKASH INSTITUTE OF TECHNOLOGY, BARGARH

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CERTIFICATE

This is to certify that DILESWAR MEHER (1601337020) bonafide student of Mechanical Engineering in Vikash Institute of Technology, Bargarh under BPUT, Rourkela has taken active interest in preparing their project report on **"CNC MACHINE USING ARDUINO"**.

This is for the partial fulfilment of the requirements for the award of ***Bachelor of Technology*** in the department of Mechanical Engineering, Vikash Institute of Technology, Bargarh for the Academic Year 2019-20.

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MECHANICAL ENGINEERING

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ABSTRACT

Computer Numerical Control (CNC) machines are used to shape metal parts by milling, boring, cutting, drilling grinding etc.. A CNC machine generally consists of a computer controlled servo amplifiers, servomotors, spindle motor and various tools. The machine can be programmed to shape a part using a front control panel. As CNC machines contain various sensitive electronic circuits for its controls, the user must provide quality input power for the machine and also should provide necessary earthing for the safety. As the costs of these machines are high, the losses due to down time of the machines are also heavy. It is found out that the fifty percent production losses from CNC machines are due to the breakdown caused because of electrical problems. The causes for most of the electrical problems are found to be originated from lack of regular maintenance, power supply fluctuations, improper earthing and unexpected power failures during machining.

INTRODUCTION

Working Principle of CNC machine is a machine that is used for automatic control in the industrial world. This machine is used to control the performance of other machines used. Both NC (Numerical Control) and CNC (Computer Numerical Control) is a term used to indicate that a manufacturing equipment; e.g. lathes, milling machines, etc., numerically controlled based computer that is able to read the instruction code N, G, M, T, and others, where the codes will be instructed to CNC machines to work in accordance with a program that had been made to do work piece to be made, Operation using CNC machines, the accuracy of a product can be guaranteed up to 1/1000 mm (microns) workmanship mass product with exactly the same result at the right time of rapid machining.

CNC machine tools equipped with a variety of cutting tools that can make precise work piece and can interpolate directed numerically (by number). CNC operating system parameters can be changed through the software program (software load program) as appropriate. CNC has been widely used in the metal industry. In this condition, CNC mechanical system used to control machines and metal cutting tools. So how thick and long pieces of metal produced by metal cutting machines, can be set by the CNC machine. This time not only the metal industry which utilizes CNC machining technology as automization process.

CNC functions in this case more displace the work of the operator in a conventional machine tools. E.g. setting work tool or regulate the movement of the chisel until the position is ready to cut, cutting motion and movement retraced early, and others. Similarly, the setting cutting conditions (cutting speed, feeding speed and cutting depth) as well as other regulatory functions such as the

replacement of a chisel, alteration, power transmission (number of revolutions of the main shaft).

NUMERICAL CONTROL MACHINE TOOL

- If each and every axis of a machine is controlled by using numbers and numerals is called as numerical controlled machine tool.

BASIC PARTS :

1. MCU or CPU
2. Drive unit
3. The feedback device
4. Taper reader system
5. Manual controls

1. MACHINE CONTROL UNIT

The MCU is working like a brain of human being i.e. it is taken the input information from input device available in the numerical control machine analyzing the data , based on the analysis it is taken some decision and this decisions will be implemented through the output device available in the numerical control machine.

Because the information given by the human being is always available in the form of high level language i.e. in decimal form but the machines can understand only low level language i.e. binary system.

The arithmetic logic unit is a part of MCU which can convert decimal to binary and vice-versa. Drive unit is a device

which can convert the electrical energy pulses into mechanical energy which is required to travelling the axis.

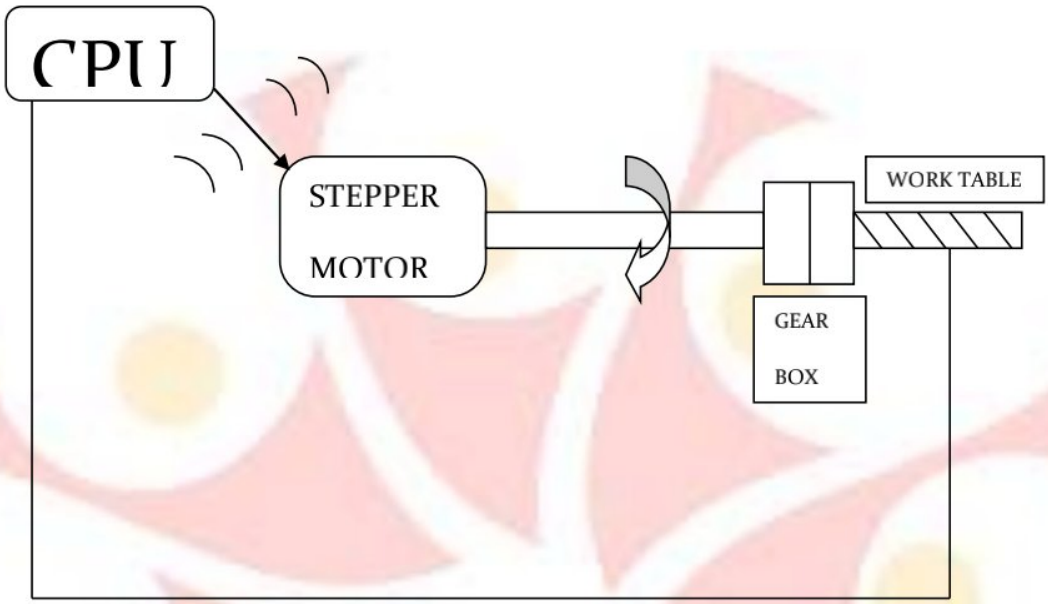
2. DRIVE UNIT

Stepper motor is taking pulse ray electrical energy as an input it is converting into mechanical energy in the form of revolutions but either by changing number of pulses of electrical energy input to the motor or by changing rate of pulses of electrical energy input it is possible to change the speed of the motor infinitely.

Incase of stepper motor even though the power supply is stopped the moving parts can not be stopped immediately because of presence of inertia effects of moving parts. Therefore the positioning accuracy of the machine becomes poor.

The servo motor is working similar to that of stepper motor but there is a quick action braking system will be available to stop the axis of motor exactly at the position wherever it is required high positional accuracy of the machine can be obtained. Hence accurate and close dimensional tolerance component can be produced and stopping all the moving parts. Therefore the positioning accuracy of the machine will be better.

At the time of development of numerical control machine the servo motor are not yet developed. Stepper motors are used as drive units in the numerical machine.



BASIC LENGTH UNIT

BLU is the linear distance travelled by the axis for 1 pulse of electrical energy input to the motor.

3. FEEDBACK DEVICE

Displacement measuring equipment mounted on the axis of machine tool. The feedback device is the displacement measuring equipment mounted on the axis of machine tool so that it is measuring the actual distance travelled by the axis and giving it as a feedback to the MCU. The MCU will compare the actual distance travelled b the axis and determining the difference in the distance corresponding to this difference in the distance the MCU will be generating the pulses and giving it to the motor. The motor is converting electrical energy pulses into

mechanical energy and giving it to the axis for travelling remaining distance once again the feedback device is measuring the actual distance travelled by the axis and giving it as feedback to MCU.

This process will continue until the difference in the distance will become less than 1 BLU. Any displacement measuring equipment which is giving the displacement output input in the form of electrical energy signal can be used as a feedback device.

The commonly used feedback device in the increasing order accuracy of displacement measurement are potentiometer LVDT, capacitance, transducer, inductance, transducer resolver, techogenerator, tachometer, encoder.

4. TAPE READER SYSTEM

The very it device used for transferring of the human being brain ideas into the machine tool is the punched paper tape with tape reader system.

PUNCHED PAPER TAP

1	2	3	4	5	6	7	8
0				0		0 0 0 0	
	0			0		0 0 0	0
		0		0		0 0 0	
			0	0		0 0	
				0			
				0			
				0			

Track number 1-4 – Alphabets

1-N (Block Number)

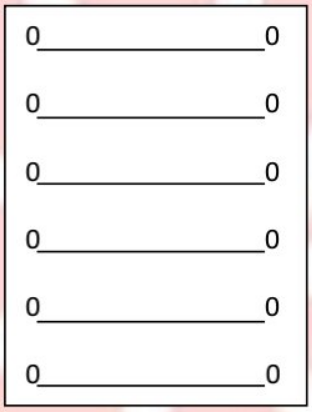
1 block of information means one compute instruction given to the machine for travelling the axis from present position to the next position.

2-X-axis

3-Y-axis

4-Z-axis

Track number 5 – Parity Check or Position Checking



Track number 6 & 7 – Number or Numerals

Track number 8 – End of block

L_f – Line of rod

In the tape reader system at one side the light source will be provided and on the other side the light receiving sensors will be provided corresponding to the each and track. Whenever the punched paper is moving and stopping at some location, whenever the holes are present through the holes the light is passing and incident on the light receiving sensor. So that the sensor is converting light energy into electrical energy and sending it to the MCU. Whenever the holes

are not present, at the places no light is passing so that the corresponding sensors are not receiving any energy. Sensor are kept quite these sensors are not sending any information to the MCU. Now whatever the sensors are sending the information to the MCU the corresponding positions are will be assumed as equal to 1 and the sensors which are not sending the information the corresponding positions is assumed as zero. Hence the instructions given on the punched paper tape has been transferred to the MCU.

5. MANUALCONTROL

Even though above basic parts are present in the numerical control machine still the manual interventions are required for loading and unloading of the component , switching on and off the machine , winding and unwinding of the tape etc. called as manual controls.

CLASSIFICATION OF NUMERICAL CONTROL MACHINE

1. Based on control system used on the numerical control machine.

a) Point to point control system
b) Straight line control system
c) Counter control system

2. Based on feedback device used
   a) Open loop system
   b) Closed loop system
   c) Number of simultaneous system

   2D, $2\frac{1}{2}$D, 3D, 4D, 5D, 6D, ……

Whenever only the end points of movements of tool is important but the path followed by the tool in between the end point is not important called as point to point control system. It is used in the case of drilling, ramming, punching, blanking etc. operations. Because of

only end points are important there is no simultaneous axis movements are required.

STRAIGHT LINE CONTROL SYSYTEM

In addition to the end points of movement of the tool if the path followed by the tool in between the end points is a straight line path called as straight line control system. This is used in turning, milling, shaping, grinding etc. operations. For this minimum two axis simultaneous movements are required.

In addition to the end points of movements of tool if the path followed by the tool in between the end points is the counter path called as counter control system. For the counter control system minimum three axis simultaneous movements are required. It is used in the case of turning, milling, grinding etc. operations.

I – Interpolation parameter for x-axis

J – Interpolation parameter for y-axis

K – Interpolation parameter for z-axis

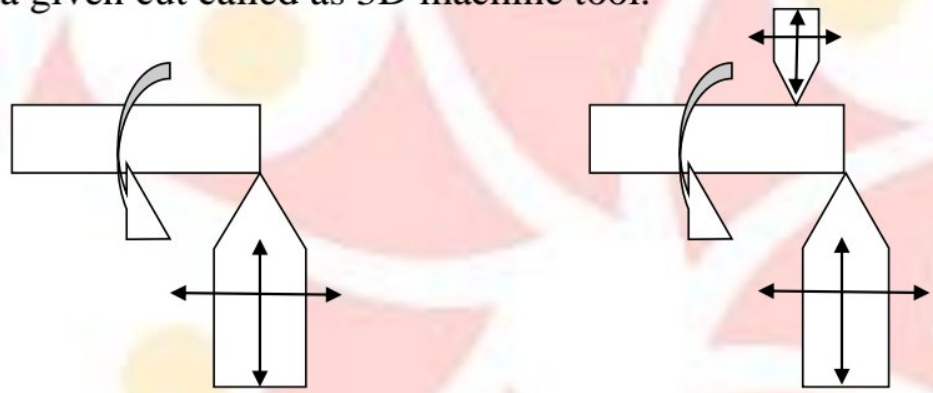
The maximum distance between two consecutive points in a counter is called interpolation parameter. (0.001 – 999.99) Even though interpolation parameter can be taken as wide range of values but the smaller the value of interpolation parameter, smoother the contour.

As the interpolation parameter is reducing the time taken for manufacturing a component is increasing and therefore the cost of manufacturing is increasing. Numerical control machine without the use of feedback device is called open loop system.

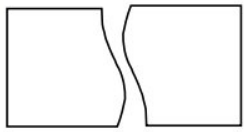
Because of no feedback device accuracy of components manufacturing is poor and it is unstable system of manufacturing.

Numerical machine with feedback device is called closed loop system. Due to the usage of feedback device the accuracy of the component produced is very good and it is fully stable system of manufacturing.

If two axis of 1 tool can be travelled simultaneously by taking the rotation of job as a spindle called as 2D machine. The spindle means the rotation of the job can nit be changed in a given cut. In addition to the two axis of 1 tool if the rotation of the job is also considered as an axis i.e. the rotation of the job also can be changed in a given cut called as 3D machine tool.



If two axis each of the two tools can be travelled simultaneously by taking the rotation of the job as a spindle is called as four axis or 4D machine tool. (5D, 6D ….). 2 and $\frac{1}{2}$D means programmable movement is possible along the three axis but the simultaneous movements are possible along two axis only. The $2\frac{1}{2}$D control system is used for producing cylindrical cam.



In $2\frac{1}{2}$D control system the rotation of the job is possible only up to 180^0 in 1^{st} setting. If a slot is required for more than 180^0 the 2^{nd} and

3rd setting will be used. After the invention of 3D machine usage of $2\frac{1}{2}$D machine becomes obsolete.

CNC VS NC

NC PARTS	CNC PARTS
1. Numerical control control	1. Computerized numerical
2. Machine control unit	2. Machine control unit
3. Drive unit	3. Drive unit
4. Feedback device	4. Feedback device
5. Tape reader system	5. Mini computer
6. Manual control	6. Very slow manual control

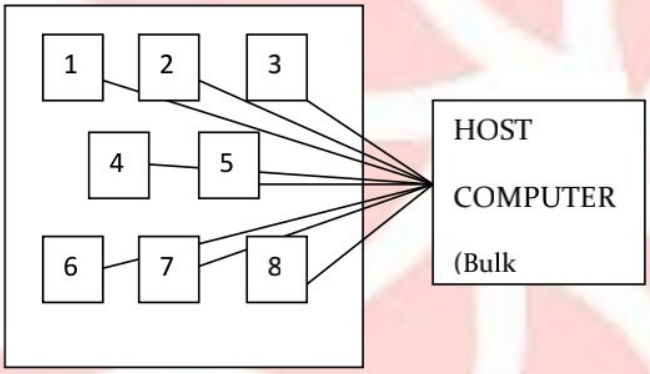
In case of CNC machine the complete tape reader system and many of the manual control are replaced by using minicomputer and the stepper motor as drive unit is replaced by using servo motor as the drive unit. Due to the above in CNC machine the feeding of the program can be done by using the keyboard and the program will be kept in the memory of minicomputer in the form of software program.

Due to this the advantages of CNC machines are

1. Because of usage of servomotor as a drive unit the positional accuracy of the machine tool is very good.
2. Feeding the program into the mini computer using keyboard is easier.
3. Because of usage of software program the life of the program is infinity.
4. Once the program is fed into the minicomputer it can be copied to a flip drive then copied to any number of machine easily.

5. During software program the design modification of the component can be incorporated into the existing program easily.
6. By using graphic stimulation software the cutter path can be generated in the minicomputer by observation it is possible to identify whether the program written write or wrong without physical manufacturing of the component.
7. Because of many of the manual control are done by minicomputer and very few manual controls are present. In the CNC machine hence complete automation or mechanization of CNC machine is possible.

DIRECT NUMERICAL CONTROL (DNC)



DNC is a system consisting of more than one CNC machine connected to the host computer through telecommunication line or local area network. So that the person sitting in front of the host computer can control all the machines in a system.

What are the program required for manufacturing of different variety of components in the industry are prepared and kept in the memory of host computer. For manufacturing of the components on the different machines the programs required will be downloaded from the host computer and kept in the memory and then given a command to asking execute the downloaded program at required number of times.

Now the system is working for producing the components. After sometime one of the machine in the system is completing its job and sending information to the host computer, the person sitting in front of the host computer is already having the schedules and according he has to do the following

1. Delete the existing program on the machine.
2. Download the program correspond to the next component.
3. Give command asking to execute the downloaded program at the required number of times.

To carry out the above three operations it will take at least 30 to 45 minutes because of very low speed of the computer. During this time one or more of the other machines also comes to the rest. They also will try to interact with the host computer but the host computer is busy with the 1st machine, like this when many machines are trying to interact with the host computer, the host computer will go into the hanging mode. This is called as traffic jam in DNC. To avoid this only limited number of machines are connected to the host computer i.e. up to 5 minutes only.

DISTRIBUTED NUMERICAL CONTROL (DNC)

As the technology is growing the cost of memory of minicomputer has been reduced therefore the memory capacity of the minicomputer of CNC machine has been increased. Due to this the programs required for manufacturing different variety of components on a machine will be downloaded and kept in the memory of minicomputer of machine itself, due to this during running of a system if the machine comes to rest and sending information to the host computer, the duty of host computer is to give one line command asking to execute the downloaded program at the required number of times. This will take less than one minute and hence within one minute the changes of getting 1st or other machines to rest is very less.

Hence the traffic jam is eliminated completely and many number of machines can be connected to the host computer.

ADAPTIVE NUMERICAL CONTROL (ANC)

During programming of the CNC machine the programmer will decide the process parameters to be used for manufacturing of components and indicating the program. Instead of this if the programmer indicates the input conditions like properties of work material, tool material, tool geometry and output requirements like criteria of machining, surface finish requirements etc. based on this if the machine itself is automatically adapting, the optimum process parameters required for machining given component called as adaptive numerical control system.

Usage of ANC system is very easy but it needs a database which is to be collected through experimentation.

MACHINING CENTER

If machine tool is capable of carrying out all varieties of operation on one machine itself is called as general purpose machine tool. If CNC is implemented in the GPM called as machining center.

Machine tool – Device capable of carrying out the machining operation or processing of material.

TOOL MAGAZINE

To carry out the different varieties of operations on machining center the different varieties of tools required will be stored in a tool storage unit called as tool magazine and it is capable of storing 32 tools at a time.

ATC

Whenever the operation is getting changing to change the tool automatically it needs an automatic tool changing unit ATC is required.

ELABORATE FIXTURE

Elaborate fixture will be used in the machining center for holding the work piece in different ways for carrying out different varieties of operations.

TRANSFER MACHINE

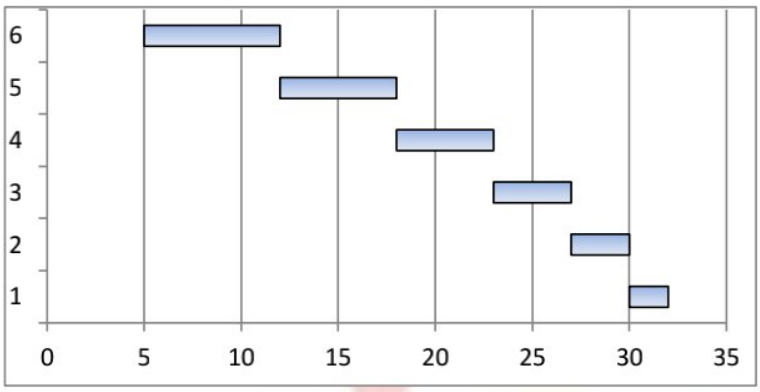
Normally in manufacturing industry a machine or machine tool means it is capable of processing of the material i.e. removing of the material and brining into the required shape. In addition to the processing, if the machine is also capable of handling the material called as transfer machine. If robotic arm is attached to the CNC machine called as transfer machine.

TRANSFER LINE

COMPONENTS :

1. Turning
2. Drilling
3. Shaping
4. Milling
5. Grinding

In the product line layout, if transfer machines are used called as transfer line. This gives the production rate which is same as that of theoretically expected value of production rate.



1- GPM
2- CNC
3- FMC
4- FMS
5- SPM
6- TL

From the above diagram FMS and FMC are used for medium volume of production with a medium variety of components called as batch production application.

FLEXIBLE MANUFACTURING SYSTEM

DNC with flexible and random movement of the material among the different machines is called as flexible manufacturing.

FMS = DNC + Flexible & random movement

= DNC + Automated guided vehicle

For producing flexible and random movement of the material among the different machines. The automated guided vehicle AGV will be used for handling the material in the system.

GROUP TECHNOLOGY

Grouping different varieties of components manufactured in the industry into a few number of groups or parts families based on

certain similarity is called group technology. The similarity used may be manufacturing or design or shape or size or material or cost etc. If FMS is implemented in each and every shop floor independently it is called as flexible manufacturing cell or cellular manufacturing.

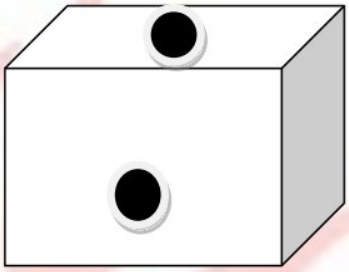
COMPUTER AIDED DESIGN (CAD)

The designing of components will be done with the use of computers is called as computer aided design.

Shaft - 10 kW power

@500rpm

Ø5mm cross hole



$\frac{T}{J} = \frac{C\theta}{L} = \frac{\tau}{R}$

$\frac{T}{J} = \frac{C\theta}{L}$ rigidity criteria

Stress concentration factor

$\frac{T}{J} = \frac{\tau}{R}$ strength criteria

Factor of safety = 2

INPUT :

1. Approximate shape
2. Landing conditions
3. Allowable stress and strength (from usage components)

PROCESS STEPS :

1. Generate 2D drawing – Drawing very fast
2. Import into analysis package
3. Convert into 3D solid model
4. Divide into many number of finite elements
5. Apply the loading conditions
6. Obtain maximum stress and strain

7. Compare with allowable stress and strain
8. Modify the dimensions of component and respect the procedure until the maximum stress and strain induced is slightly less than the allowable stress and strain
9. Finalize the design

OUTPUT :

1. 2D drawing
2. Bill of materials
3. The maximum stress and strain

From the above basic difference between conventional and computer aided design is

1. In the conventional design the tool body will be considered as a single element and the analysis will be carried out only a single element only. Therefore the analysis will be difficult and less accurate where in CAD because of the component is divided into many number of finite elements and elemental analysis will be carried out hence the analysis will be easier and more effective.
2. To account for the change in cross-section, the stress concentration factor can be considered in the conventional design where as in case of CAD because of elemental analysis the changes in cross-section has been automatically taken care. Hence no stress concentration factor is to be taken.
3. In conventional design to account for the uncertainties present during usage of component, at least two will be taken as a factor of safety. Where as in CAD because of elemental analysis most of the uncertainties has been taken care already hence the maximum factor of safety 1.25.

4. In case of conventional design, it is difficult and time consuming to incorporate the design modification. Where as in CAD it is very easy to incorporate the design modification.

COMPUTER AIDED MANUFACTURING (CAM)

ASRS + FMS + CMM = CAM

INPUT

1. 2D production drawing
2. Bill of material
3. Raw material

PROCESS

1. Generate the CNC part program
2. Retrieve the raw material
3. Processing of material
4. Inspection

OUTPUT : Accepted components

CAD – CAM INTEGRAL APPROACH

CAD – CAM –s integral approach used for design and manufacturing of the components together. So that without the manual intervention the components can be manufactured together automatically.

Input = Input of CAD

Process step = process steps of (CAD + CAM)

Output = Output of CAM

MEDIUM DENSITY FIBREBOARD

MDF is a type of hardboard, which is made from wood fibres glued under heat and pressure. It may be used to make display cabinets, wall-panels and storage units.

PART PROGRAMMING OF CNC MACHINE

Programming of CNC machine by using a standard code is called as part programming of CNC machine.

Code – Program written for standard movement of tool

The standard code is nothing but the name given to the program written for standard movement of the tool.

G-code –General Purpose code

(G00 to G999) G00 – rapid transverse

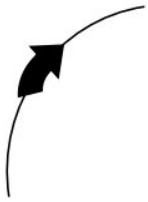
Whenever the tool is required to travel ideally, the G00 code will be used. So that the machine is automatically adapting the maximum possible velocity in the machine tool.

G01 – Straight line movement or linear interpolation

Whenever the tool is required to travel in a straight line path the G01 code will be used.

G02 – Circular Interpolation Clockwise

G03 - Circular Interpolation Counter Clockwise

G02  G03 

G04 – Dwell G05 – Hold G04 F120

F120 indicates the temporary stoppage of the machine and tool for specified duration of 120 second.

Hold is nothing but temporary stoppage of the machine and tool for unlimited duration.

G08 –Acceleration G09 - Retardation

Even though high speed is indicated in the program, to start the machine at low speed and reach to the required amount of speed in a specified duration the acceleration code G08 will be used.

The G08 and G09 has been made as a default codes in the today's latest version of CNC machine.

G17 – XY plane G18 –YZ plane G19 – ZX plane

G33 – Thread cutting with constant pitch

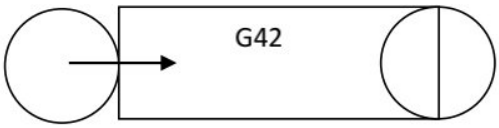
G34 - Thread cutting with increasing pitch

G35 - Thread cutting with decreasing pitch

Increasing Pitch 

G41 – Tool radius compensation left

G42 - Tool radius compensation Right



System will automatically calculate the approach 1. We need to indicate all these value.

G70 – English Programming G71 – Metric Programming

If the values of tool movement is indicate in terms of inches is called English programming and if the values of tool movement is indicate in terms of mm is called as metric programming. The latest CNC system G71 has been made as a default code.

In terms of inches – G71 is the default code

G90 – Absolute mode of programming

G91 – Incremental mode of programming

If each and every movement of the tool is indicated with reference to only one single reference point called as absolute mode of programming.

If present position of the tool is taken as reference point for program to the next position of the tool is called as incremental mode of programming.

1-2, 2-3, 3-4 ⟶ Incremental mode of programming

0-1, 0-2, 0-3 ⟶ Absolute mode of programming

Even though incremental mode of programming is easy to write and modify but according to the Indian condition it is always recommended to use absolute mode of programming only.

During running of the program if the power failure occurs and after restoring the power it is difficult to identify location where the program has got stopped if the program is written in incremental mode but it is very easy to identify the location where the program has got stop if the program is written in absolute mode.

ARDUINO

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or breadboards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers can be programmed using C and C++ programming languages. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

GRBL SHIELD

GRBL Shield is a shield that plugs onto the Arduino development platform transforming it into a CNC controller using the GRBL CNC firmware. The Arduino GRBL Shield is a complete hardware solution for Dank's CNC motion control system called GRBL.
Compatible with the Uno and other 328p versions of the Arduino development platform. (Note: GRBL 0.6 is not compatible with 168-based Arduino (nor will it ever be), and currently GRBL does not support the Arduino Mega).

GRBL FEATURES :

- Interprets a subset of rs274/ngc standard gcode
- Three motion control axes – X, Y and Z
- Full support for arc motion
- Acceleration / deceleration management

GRBL SHIELD FEATURES :

- Compatible with grbl 0.6 and later versions
- Three stepper motors supporting X, Y and Z axes
- 8x microstepping
- 2.5 amps per winding (bipolar steppers)
- 12v-30v motor voltage supported
- Independent current control per axis
- Motor connectors plug compatible with RepRap and Makerbot electronics
- Uses TI DRV8818 stepper drivers

BEARING

A flexure bearing is a category of flexure which is engineered to be compliant in one or more angular degrees of freedom. Flexure bearings are often part of compliant mechanisms. Flexure bearings serve much of the same function as conventional bearings or hinges in applications which require angular compliance.

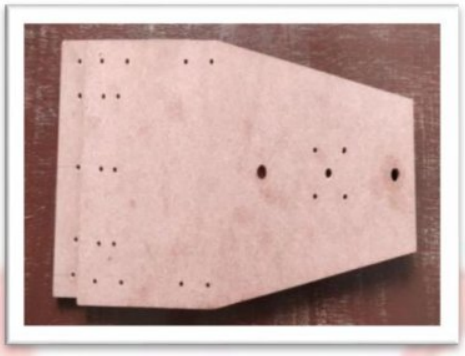
STEEL ROD

Steel rods are made from an iron alloy with carbon and other elements that modify the material to achieve specific properties. ... There are several production and finishing options available for each type, including polished and hot rolled **steel rod**.

ASSEMBLY

BASE :- The materials that we will require for this are the motor frame, the idler frame and 2 side frame. In the motor frame big hole is for the motor shaft and the small hole at the sides are to fixed the motor using screw. The 8mm holes at the corner of the motor and idle frame on both sides are used for fixing the steel rods and the hole in the centre of the idle frame is for the lead screw. The 3mm twin holes that see on the sides of the frame are used for fixing clamp to the frame.

Y-AXIS :-

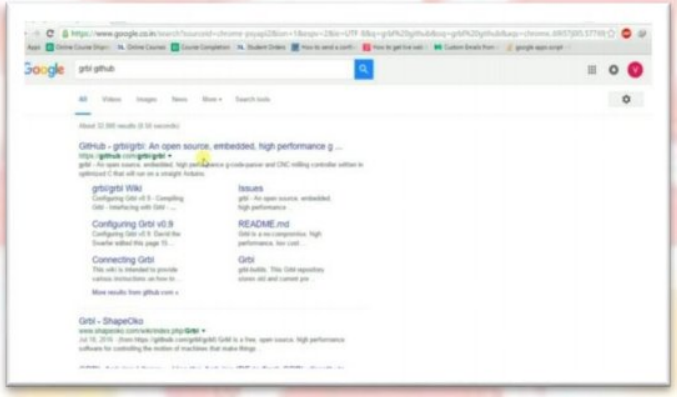


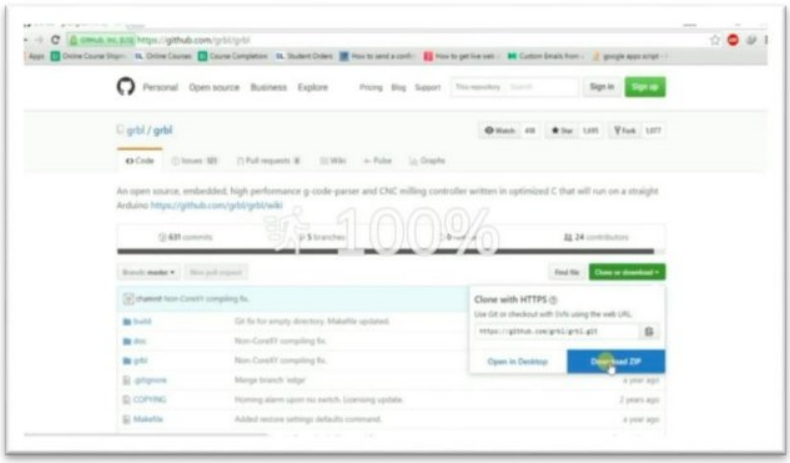
Z-AXIS :-

Mounting the X-Z Axis Assembly on the Y-Axis Gantry :-Take one of the Y-axis frame and fixed it to the base using the steel rod, pass the steel rods through the base frame and bearings of the Y-axis frame. Do the same for the other Y frame as well make sure the frame moves freely. Finally we need to fixed the X-Z assembly to this assembly. So take the X-Z assembly that we made earlier and passed steel rods through the Y frames and the bearing on the X-axis frame.

PROCEDURE TO SETUP GRBL SHIELD WITH ARDUINO

Download the grbl master from grbl github and upload the file onto the arduino board. The command written here uploads all the library files which contain functions and commands to operate the different components in a CNC machine with the help of the GRBL shield.

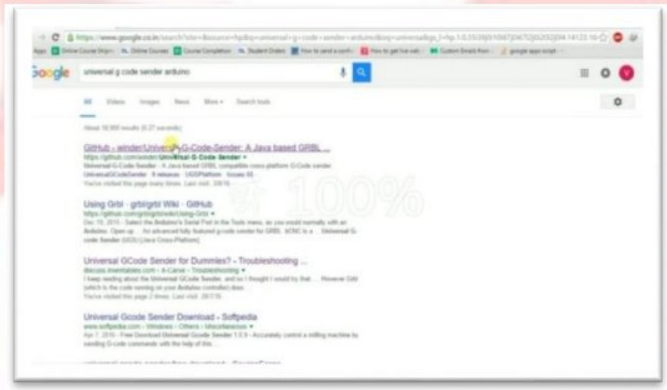


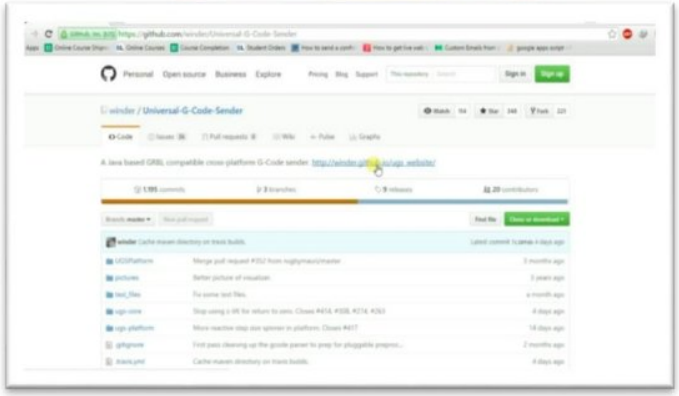


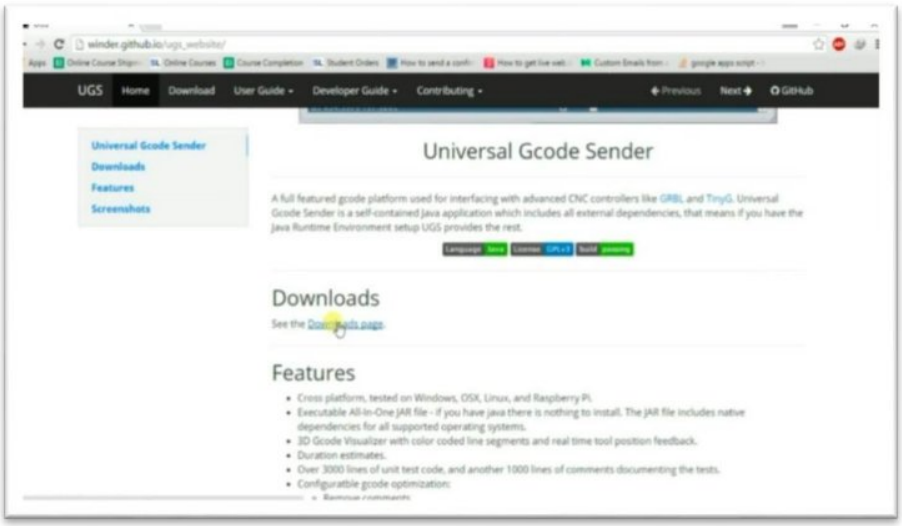
UNIVERSAL G-CODE SENDER

The G-code sender is a platform used for interfacing PC with advanced CNC controller like the GRBL to install the G-code sender go to the link and download version 1.0.9 of the G-code sender. Then extract the contains of the folder to open the G-code sender application. Once we have connected the arduino board to laptop with the USB cable. Open the G-code sender and select the port to which the arduino board is connected from the list of ports available for serial communication. Set the baud rate to 115200 and click on open. This command open the connection between PC and the GRBL shield. As soon as to connect arduino and GRBL shield we will be able to see the machine status which is currently in ideal state. Under

the machine control tap we have command which can be used to control the CNC machine. Here we can command the machine to move with the help of the X,Y,Z buttons shown on the right side. Each click of a button will cause a movement along that axis in the order of the step size mention. You can change the dimension and the amount of step that we prefer. As we click on the buttons use for movement we can see the respective G-code command being executed in the console and the current position of the machine tool respect to origin. Under the file mode tap we can browse and select text file in which G-code for a specific process is written. Open the text file and click on visualize. In the visualization panel we can see the number of layers of machining to be performed and pattern that the machine tool will have follow. Then we can click on send under the file mode tapand allow the CNC machine to perform the required operations.



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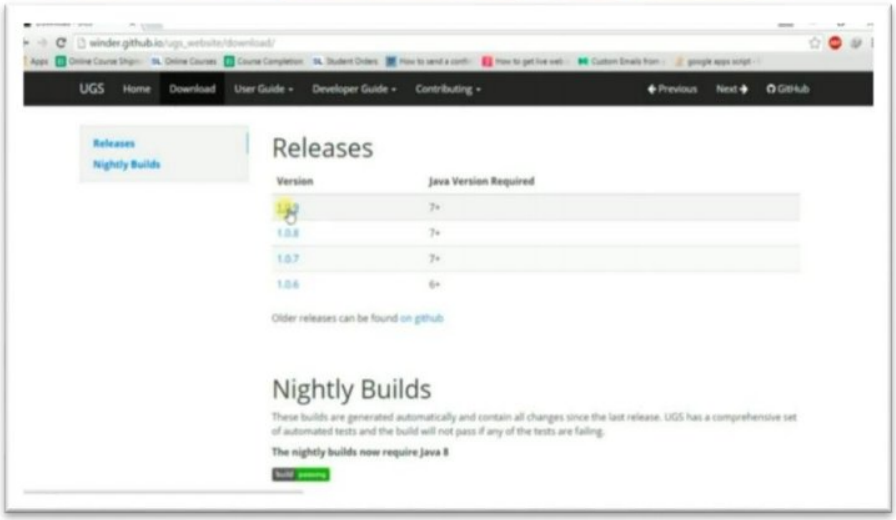
Universal Gcode Sender
Downloads
Features
Screenshots
Universal Gcode Sender
A full featured gcode platform used for interfacing with advanced CNC controllers like GRBL and TinyG. Universal Gcode Sender is a self-contained Java application which includes all external dependencies, that means if you have the Java Runtime Environment setup UGS provides the rest.
Downloads
See the Downloads page
Features
Cross platform, tested on Windows, OSX, Linux, and Raspberry Pi.
Executable All-In-One JAR file - if you have java there is nothing to install. The JAR file includes native dependencies for all supported operating systems.
3D Gcode Visualizer with color coded line segments and real time tool position feedback.
Duration estimates.
Over 3000 lines of unit test code, and another 1000 lines of comments documenting the tests.
Configurable gcode optimization:


winder.github.io/ugs_website/download/
UGS
Home
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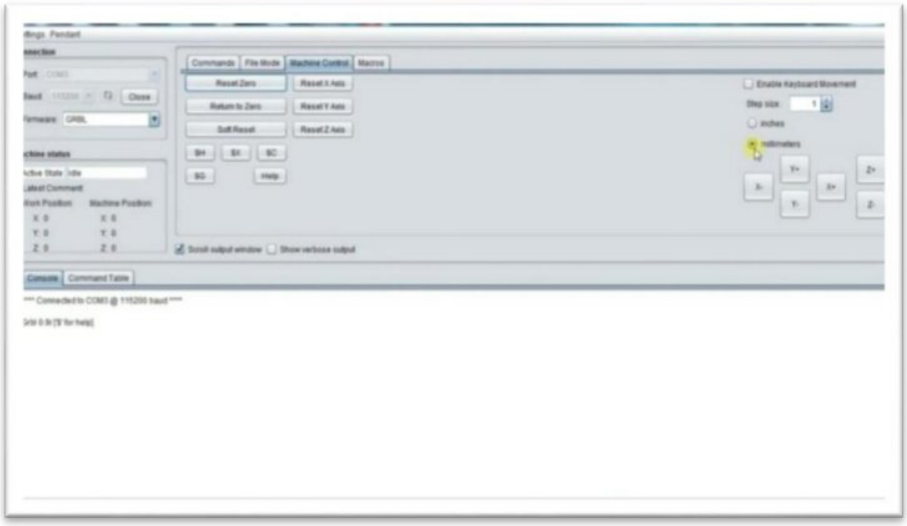
Developer Guide
Contributing
Previous
Next
GitHub
Releases
Nightly Builds
Releases
Version
Java Version Required
1.0.8
7+
1.0.7
7+
1.0.6
6+
Older releases can be found on github
Nightly Builds
These builds are generated automatically and contain all changes since the last release. UGS has a comprehensive set of automated tests and the build will not pass if any of the tests are failing.
The nightly builds now require Java 8


Commands
File Mode
Machine Control
Macros
Reset Zero
Reset X Axis
Return to Zero
Reset Y Axis
Soft Reset
Reset Z Axis
Close
Enable Keyboard Movement
Step size
inches
millimeters
Help
Scroll output window
Show verbose output
Console
Command Table

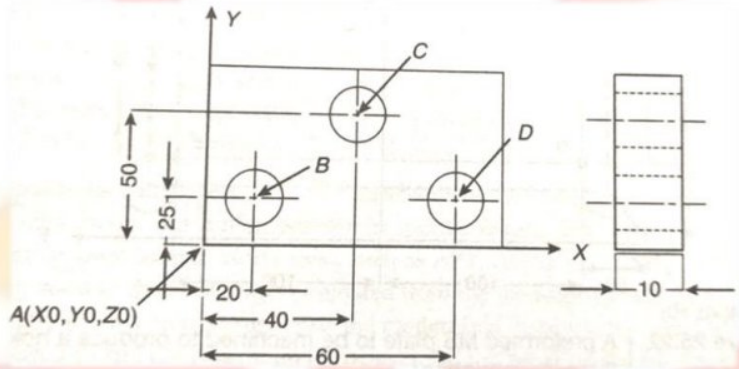
	CNC GCODE LIST
GO1	Linear interpolation
G02	Circular interpolation CW
G03	Circular interpolation CCW
G04	Dwell
G17	X Y plane selection
G18	Z X plane selection
G19	Y Z plane selection
G28	Return to reference position
G30	2^{nd}, 3^{rd} and 4^{th} reference position return
G40	Cutter compensation cancel
G41	Cutter compensation left
G42	Cutter compensation right
G43	Tool length compensation + direction
G44	Tool length compensation – direction
G49	Tool length compensation cancel
G53	Machine coordinate system selection
G54	Work piece coordinate system 1 selection
G55	Work piece coordinate system 2 selection
G56	Work piece coordinate system 3 selection
G57	Work piece coordinate system 4 selection
G58	Work piece coordinate system 5 selection
G59	Work piece coordinate system 6 selection
G68	Coordinate rotation
G69	Coordinate rotation cancel
G73	Peck drilling cycle
G74	Left-spiral cutting circle
G76	Fine boring cycle
G80	Canned cycle cancel
G81	Drilling cycle, spot boring cycle
G82	Drilling cycle or counter boring cycle
G83	Peck drilling cycle
G84	Tapping cycle
G85	Boring cycle
G86	Boring cycle

G87	Back boring cycle
G88	Boring cycle
G89	Boring cycle
G90	Absolute command
G91	Increment command
G92	Setting for work coordinate system or clamp at maximum spindle speed
G98	Return to initial point in canned cycle
G99	Return to R point in canned cycle

	CNC M Code List
M00	Program stop
M01	Optional program stop
M02	End of program
M03	Spindle start forward CW
M04	Spindle start reverse CCW
M05	Spindle stop
M06	Too change
M07	Coolant ON – Mist coolant/Coolant thru spindle
M08	Coolant ON – Flood coolant
M09	Coolant OFF
M19	Spindle orientation
M28	Return to origin
M29	Rigid tap
M30	End of program (Reset)
M41	Low gear select
M42	High gear select
M94	Cancel mirror image
M95	Mirror image of X axis
M96	Mirror image of Y axis
M98	Subprogram call
M99	End of subprogram

Lets take an example of a plate to be drilled in a milling machine or machining centre. (Drilling Only)

Q. Three through holes of 16 mm diameter are to be drilled in a 10 mm thick steel plate as shown in figure. The left bottom corner (point A) of the pre-machined plate or any other suitable point may be taken as the reference point in XY plane. The program can be written in both absolute and incremental dimensioning and both in inch or mm dimensioning.



Ans : A suitable part program for such a drilling requirement can be written as follows :

N001 G92 X0 Y0 Z0 (presetting at A)

N002 G90 (absolute dimensioning)

N003 G00 T001 S20000 M03 (select tool and speed)

N004 G00 X20 Y25 Z2 (rapid locating at B & 2mm above surface)

N005 G01 G95 Z-12 F0.05 (drill hole at B)

N006 G00 Z2 (rapidly lift the drill)

N007 G00 X40 Y50 (rapidly shift, 2mm above point C)

N008 G01 G95 Z-12 F0.05 (drilling at location C)

N009 G00 Z2 (rapidly lift the drill)

N010 G00 X60 Y25 (rapidly shift 2mm above point D)

N011 G01 G95 Z-12 F0.05	(drill hole at D)
N012 G00 Z2	(lift the drill)
N013 G00 X0 Y0 Z0	(rapidly return to point A)
N014 M30	(program and work stop)

ADVANTAGES

1. CNC machines can be used continuously 24 hours a day, 365 days a year and only need to be switched off for occasional maintenance.
2. CNC machines are programmed with a design which can then be manufactured hundreds or even thousands of times. Each manufactured product will be exactly the same.
3. Less skilled/trained people can operate CNCs unlike manual lathes / milling machines etc.. which need skilled engineers.
4. CNC machines can be updated by improving the software used to drive the machines
5. Training in the use of CNCs is available through the use of 'virtual software'. This is software that allows the operator to practice using the CNC machine on the screen of a computer. The software is similar to a computer game.
6. CNC machines can be programmed by advanced design software such as Pro/DESKTOP®, enabling the manufacture of products that cannot be made by manual machines, even those used by skilled designers / engineers.
7. Modern design software allows the designer to simulate the manufacture of his/her idea. There is no need to make a prototype or a model. This saves time and money.
8. One person can supervise many CNC machines as once they are programmed they can usually be left to work by themselves. Sometimes only the cutting tools need replacing occasionally.
9. A skilled engineer can make the same component many times. However, if each component is carefully studied, each one will vary slightly. A CNC machine will manufacture each component as an exact match.

DISADVANTAGES

1. CNC machines are more expensive than manually operated machines, although costs are slowly coming down.
2. The CNC machine operator only needs basic training and skills, enough to supervise several machines. In years gone by, engineers needed years of training to operate centre lathes, milling machines and other manually operated machines. This means many of the old skills are been lost.
3. Less workers are required to operate CNC machines compared to manually operated machines. Investment in CNC machines can lead to unemployment.
4. Many countries no longer teach pupils / students how to use manually operated lathes / milling machines etc... Pupils / students no longer develop the detailed skills required by engineers of the past. These include mathematical and engineering skills.

FUTURE SCOPE

Just a few years ago, 3D printing was nothing more than an afterthought for many individuals. Now it appears as if it could completely replace what we've come to know as traditional manufacturing methods. Known as additive manufacturing, 3D printing builds layers of materials to create objects. 3D printers are currently available on the market, and many are very reasonably priced and are being used by individuals in their homes for what is essentially personal manufacturing.

As for CNC technology, CNC machines have already begun to drop price and are becoming more readily available to the public. Expect to see a continued decrease in the price of these machines. Plus, they've become easier to use, and you don't have to be a math whiz or have manufacturing experience to both assemble and utilize a CNC mill, lathe, or plasma cutter. The main difference between CNC

machines and 3D printers is that CNC tools take away or subtract materials for large pieces to create an object, where as 3D printers add materials.

BILL OF MATERIALS

Item	Description	Quantity	Estimated Cost(Rs.)
1	MDF BOARD (8mm)	8pc.	2080 /-
2	GRBL Shield	1	2000/-
3	Arduino	1	
4	Bearing	16	1000/-
5	Bearing Holder	16	
6	Steel rod	8	1000/-
7	Screw thread rod(M8)	3	1500/-
8	Nut & Bolts	100pc.	600/-
9	Stepper Motor	3	1500/-
10	Motor (1000 RPM)	1	1200/-
11	Drill bit/ Tool	1	500/-
12	Power Supplier	1	1200/-
13	Switch & Wire	1	100/-
14	Frame Setup	1	4780/-
15	Accessories		2320/-
Total			19780/-

CONCLUSION

In last two decades, a lot of remarkable process has taken place, leading to development and commercial use of FMS (Flexible Manufacturing System) and CIM (Computer Integrated Manufacturing) by incorporating CAD-CAM integration, Use of robots (loading,unloading,warehouse handling, inspection and assembly), Group technology, Mechatronics and sensors.

The dedicated microcomputer replaced by software enabling very fast and precision control, storage of huge information and user-friendliness. CNC machine tools are also versatile,flexible,productive and cost effective that, unlike NC machine tools, CNC machine tools are surviving and being used increasingly over several decades for piece production,batch production and even lot production.

REFERENCES

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3. "Metal cutting" by A Bhattacharya
4. "Machining And Machine Tools" by A.B.Chattopadhyay
5. "Computer Numerical Control" by Steve Krar and Arthur Gill
6. "CNC Programming Handbook (3rd edition)" by Peter Smid