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Fabrication of Low Cost CNC Engraving Machine

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***Abstract:** When the name of CNC comes up the first thing that comes in our minds is that high degree of surface finish can be achieved but also at a higher cost. Most of the conventional CNC machines available in the market are very costly. But there is an alternative available to us in the market. Micro-controllers, nowadays are becoming very famous because at a reasonable cost we can achieve a remarkable similarity in the working and operation as in comparison to the big sized controllers. Micro-controller namely the Arduino and GRBL coupled system can operate the tool with such intricacy that we can even sometimes not achieve with the conventional CNC machine. There is one more advantage of this kind of desktop CNC that very small work pieces can be machined which sometimes is not possible on larger size CNC.*

I. INTRODUCTION

In the modern CNC machines, all the work is carried in integration to the computers hence it is a fully computer integrated mechanism. In order to achieve a computer integrated manufacturing various software are required which work in integration with the machine and the computer. In this CNC the software portion is used to send the signals or the commands which are then converted into the machine language which further on controls the machine and in accordance with the commands the machine functions and provides the required motion and function. The micro-controllers which is the Arduino based controller is housed with the GRBL shield and stepper motor drivers and also a heat sink on the top in order to dissipate the heat.

The main aim of our project was to make the whole machine as low cost as possible as one of the advantages. For that the first step was to use a cheaper and reliable material from various sources one material came up which was the medium density fibreboard or commonly known as the MDF. After the material, another aspect was to lower the cost of the controller, and as we know about the micro-controller this problem was also solved and also this was one of the important aspects in this project as the controllers are very costly. All the components are standard which are used in the larger size CNC, but the main differences the larger sized components get smaller. The 3 axis CNC as the name suggests works in the 3 dimensional plane and namely there are three axis, x,y,z axis. The other components of the CNC are namely the lead screw, bearings, journals which support the assembly, stepper motors, couplings which are used to couple the motors and lead screw, dc motor, tool, chuck, etc.

Fig.1 , Comparison of the conventional CNC and Desktop size CNC

II. OBJECTIVE OF PAPER

The main idea behind the construction of the low cost CNC machine is that the processes which are done on the larger size CNC machines can be done on the small scale machine and that too at a very low cost. The CNC machines of small size are having a very easy operation and are very easy to understand. The interface which is used to run the setup is also very easy to operate as we just have to input the commands in the forms of the G and M codes. CNC Router using Arduino-based control system is presented with following specifications:

A. Low cost
B. Easily operable

C. Easy interface
D. Flexibl
E. Low power consumption
F. Portable

Computer Aided Design of this system

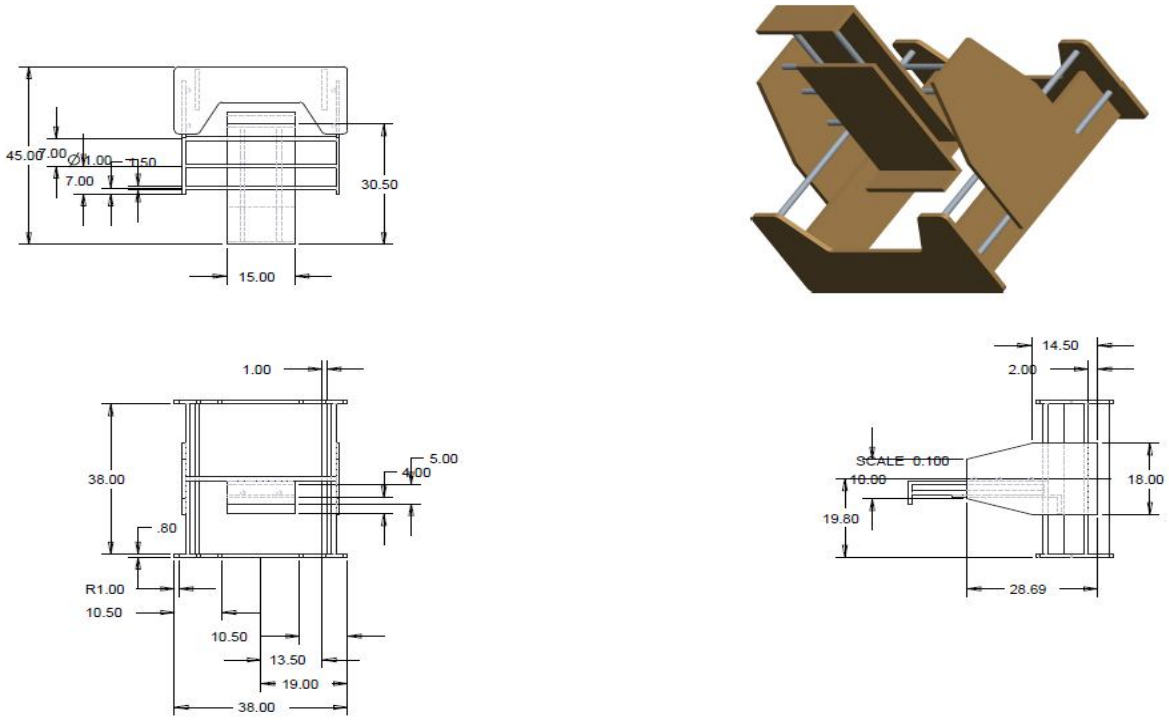

Figure 2 CAD design

III. METHODOLOGY

This system has been divided in to three segments. As shown in figure 8 Mechanical segment gets electronic control signals from the electronics segment which ultimately results in actuation of motors and achieving motion to perform the particular machining operation. Electronics segment gets the set of commands from software segment and generates controls for mechanical segment.

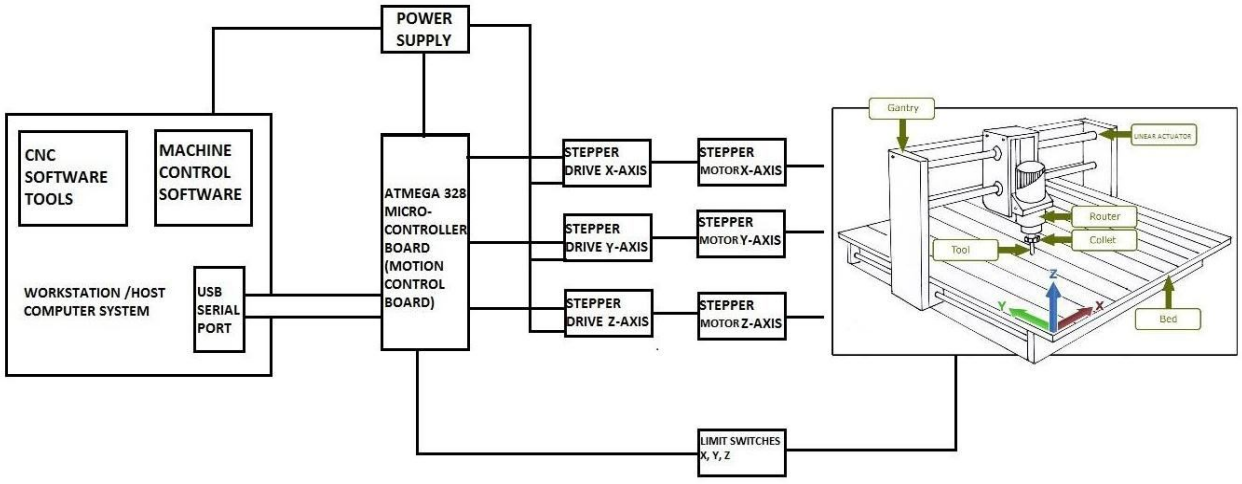

Fig 3. Block diagram of overall process

The working methodology of system is well explained in the above The detail explanation of three modules has been explained along with proper components

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IV. MECHANICAL SYSTEM

The mechanical system is the most important part of the system as the end result is to be delivered through it.the precision and accuracy of it depends upon the rigidity of the system. The mechanical system is made by various components as follows:

A. Frame

The frame is the most important part of mechanical design process as the stability and the rigidity of the system is dependent totally on the material and the assembly of the system. In this system the MDF material is used in order to reduce the cost of the system and fulfil the basic strength related properties.

B. Lead Screws

A lead screw is a mechanical linear actuator which is used to convert rotatory motion in to linear motion by means of threads which minimum friction. The thread on the lead screw are of various types depending on the purpose and loads acting on the leadscrew.the acme threaded lead screw is used for this system so it can withstand high thrust loads along with minimum internal friction.

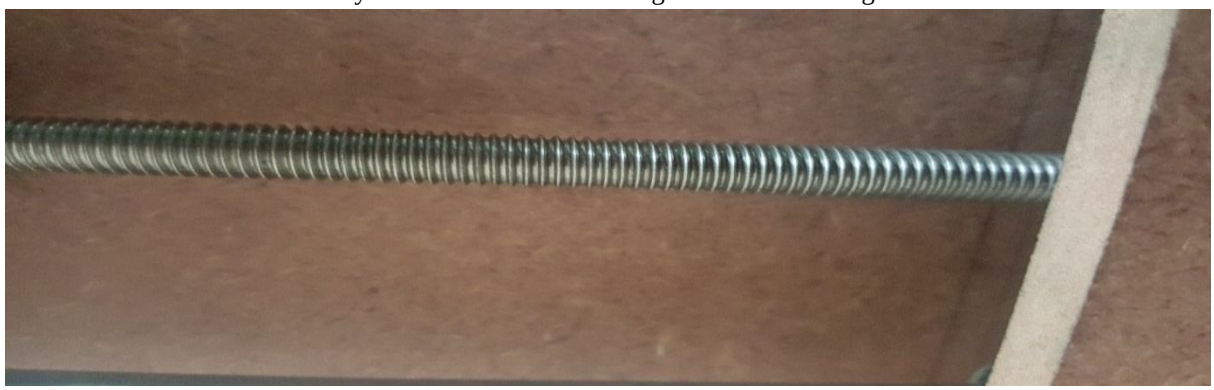

Fig 4. Lead screw

C. Ball Bearings

A ball bearing is a type of rolling-element bearing in which balls are used to separate the bearing races with sole purpose to reduce rotational friction between the surfaces and support radial and axial loads.

Fig 5. Ball bearing

D. Linear Rods

Linear rods are rigid strong Mild Steel shafts which are used to carry the load and provide support to linear movement the motion isn't affected. Linear bearing assembly are used to carry the loads and supports the structure's in linear motions the total load of the structure is taken away by the linear and therefore the load on ball screw is reduced and causes precise smooth linear motion.

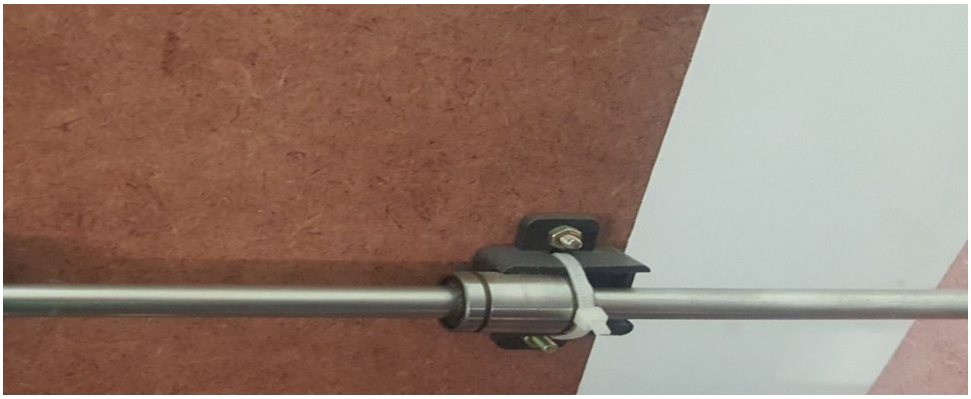

Fig 6. Linear rod bearing assembly

E. Shaft Couplings

A Shaft Coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. In our system the coupling is used to transmit power from the stepper motor shaft to the lead screw in order to achieve linear axis motion.

F. Tool Chuck

The chuck is provided in order to provide flexibility to change tools as per operation as well as to provide rigidity in holding the tool. Various types of tools are available but collet chuck is used in this system as it fits the best in design.

G. Stepper Motor

A stepper motor is a brushless, synchronous electric motor which converts digital pulses into mechanical shaft rotation in a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller).In this system NEMA stepper motor with following specifications is used in this system

Voltage: 12v-24v
Shaft Diameter: 5mm
Step Angle: 1.8 deg/step
Torque: 4.2kg-cm

V. ELECTRONICS SYSTEM:

Electronics segment is used to generate control signal to the stepper motors which will guide the motion of tool in the required path or axis. Electronics segment consists of

A. Power supply

For the power supply SMPS is used to convert the AC voltage to DC voltage and supplies required voltages to the remaining electronic parts. Microcontroller board receives 12v supply whereas the stepper motor board receives 24v.

Fig 7. Switched mode power supply

B. Microcontroller Board

Atmega 328p Arduino based microcontroller development board is used in this system to control the motion of the system. It behaves as the brain of this CNC system which receives the commands from the software system from computer software connected through the USB serial port. Arduino development board is flashed with the GCODE interpreter code which was written in the C language, which is responsible to generate the control signal for corresponding command signal from the computer system to the stepper motors which directly controls the motion of the tool path. The commands from computer or software system are received and convert them to the actual electronic signals to the Stepper Motor Driver Board.

C. Stepper Motor Driver Board

RMCS-1102 is micro-stepping drive designed for smooth and quiet operation is chosen to drive the NEMA 23 stepper motor. Stepper motor Driver Board receives the control signal form the microcontroller board
to the terminals PULSE and DIR which generates the corresponding digital pulse signals for 4 Lead stepper motor to control the rotation of the motor.

D. Software and Coding System

The CAD software is used to generate the graphical representation which is then transferred to the CAM software which generates the M and G codes for the input of the CNC control software which then converts to the machine language which is sent to the Arduino UNO to achieve the motion,

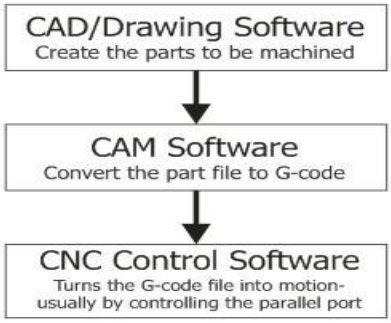

Fig 8 software tool chain

1) *Cad Software:* CAD is used to generate design ,engineering drawings,3d files and basic design for the CAM software using .prt and other similar formats based on parameters. OpenSCAD, FreeCAD, HeeksCAD PTC Creo (formerly PTC Pro/Engineer), Dassault Solidworks, Autodesk Inventor, Auto CAD are some examples of CAD packages.
2) *Cam Software:* Computer Aided Manufacturing, or CAM, is used to convert the cad file to the.stl format for interpretation in machine language. Some example packages are like CAD/CAM, G-Simple, FreeMill, Dolphin CAD/CAM, CamBam, Vizion (ArtCam), OneCNC, VirtualGibbs, MasterCAM , BOBCAD-CAM, MeshCAM, VisualMill, TurboCADCAM, DeskCNC, SheetCAM, OneCNC, SprutCam, EdgeCAM, ArtCAM etc.
3) *cnc control software (Gcode Sender):* Gcode Sender is used to send the G-code files to arduino uno controller.Gcode Sender will take a G-code program in file and then send it line-by-line. The Gcodes will send the data via serial ports through USB cable between the computer and microcontroller. GCode universal sender is software that is designed to send GCode to CNC machines is , such as 3D milling machines.

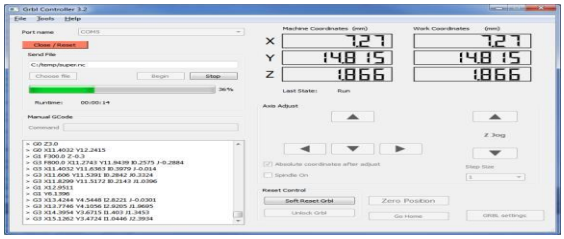

fig 9 cnc control software window

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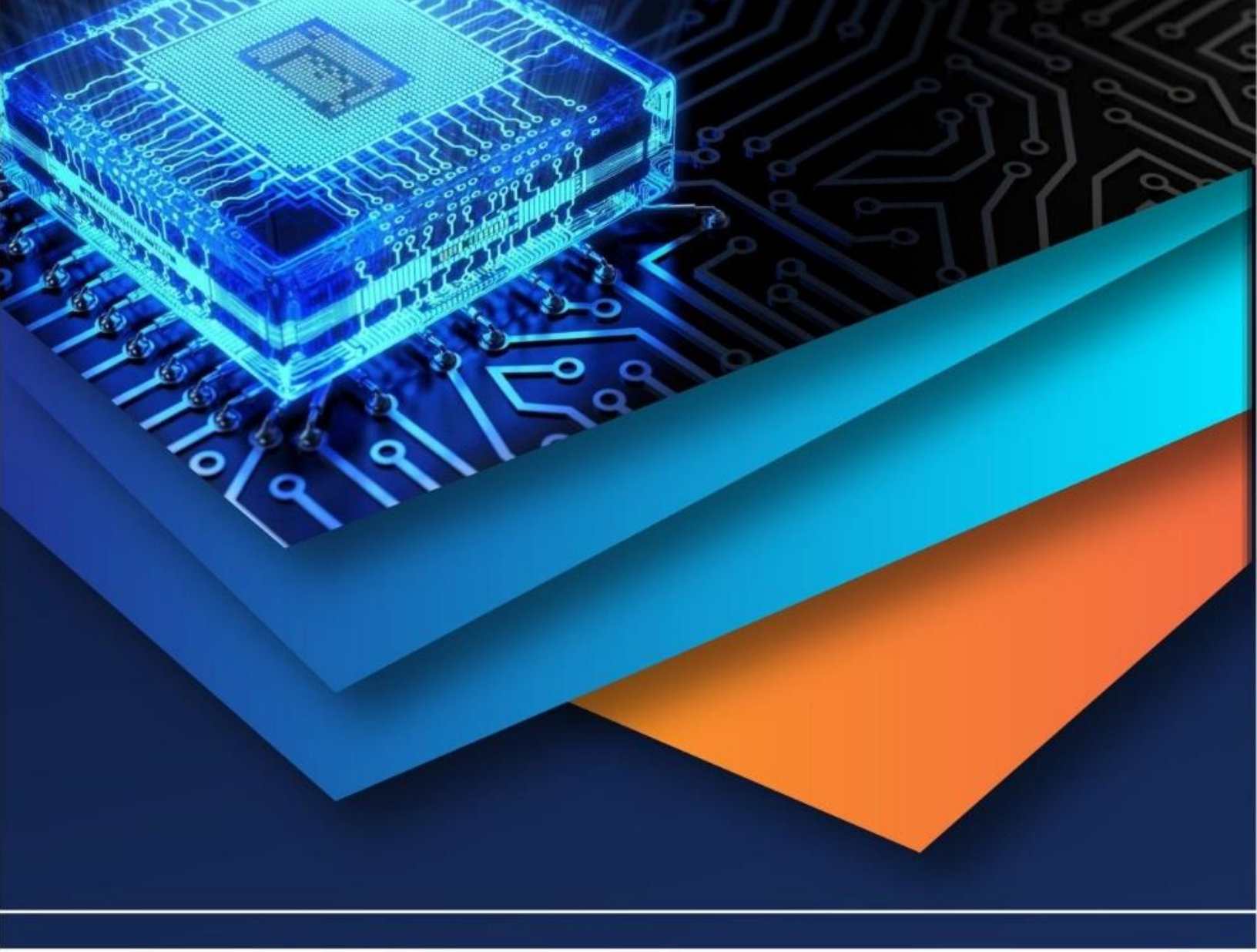

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