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# Design and Fabrication of Automatic Wood Drilling Machine

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## ABSTRACT
*CNC is a Computerised Numerical Control machine which is widely used in today's major industries to increase the production rate and thus the profit. It makes utilisation of latest electronic and software developments to bring automation along with ease of being operated in less time. Thus, high degree of advancement in machine comes with very high cost thus increases the capital cost. It is sometimes impossible for start-ups & small scale industries to afford them. This paper aims to design and fabricate an automatic vertical drilling machine for point to point drilling in wooden planks. The system consists of two main parts: a mechanical setup that can move in X, Y and Z directions, and a software program that controls overall operation of the whole system. We show that our system successfully performs both of the above tasks. Operator would put coordinates of proposed holes in the given graphical window on computer. The drilling machine will travel to the respective co-ordinates with lead screw mechanism which is driven by stepper motor, being controlled by Arduino Mega microcontroller. This paper emphasises on implementation and testing of suitable mechanism and software to bring automation and accuracy with negligible cost. It also enables lesser skilled operators to create components using CNC mechanism.*

***Keywords——Drilling Machine, CNC Machine Design, Visual Basics Graphical User Interface, Low Cost Automation, Arduino Mega Microcontroller.***

## I. INTRODUCTION
Computer Numerical Control (CNC) drilling machine plays an important role in today's manufacturing processes. CNC machines have advanced the holes drilling process as this manufacturing process now has been completely automated. CNC drilling machine can be classified as CNC Printed Circuit Board (PCB) drill, CNC vertical drill, CNC deep-hole drill, drilling center and otherlarge CNC drilling machine [1], [2]. This machine is used for drilling holes with numerical control and widely used in hole processing technology for the PCB [3].

A drilling machine is a device for making holes in components. The manually operated type of drilling machine creates problems such as low accuracy, high setup time, low productivity, etc. A CNC machine overcomes all these problems but the main disadvantage of a CNC drilling machine is the high initial cost and requirement of skilled operator for operating the machine. Hence, there arises a need for a low cost CNC machine which can not only drill holes with high accuracy and low machining time but also have low initial cost [4]. The need for skilled operator is eliminated by providing software with a more user friendly graphical user interface.

## II. DESIGN CONSIDERATIONS
*A.Work Piece Size*

As a basis for further development of the drilling machine, the maximum component size (maximum travel along the axis) is selected as:

1. X = 400 mm.
2. Y = 400 mm.
3. Z = 20 mm

*B. Configuration Selection*

The different configurations are considered from fabrication point of view, and it is found that the gantry configuration is most suitable because of the following qualities.

1. Provides better rigidity.
2. Better accuracy.
3. Ease of operation and programming

*C. Drilling Machine Components*

The drilling machine is divided into two sub systems. These are:

1. The mechanical setup.
2. The software program.

## III. MACHINE DESIGN

Machine structure is the "backbone" of the machine tool. It integrates all machine components into a complete system. The machine structure is crucial to the performance of the machine tools since it is directly affecting the static and dynamic stiffness, as well as the damping response of the machine tool. A carefully designed structure can provide high stiffness, result in higher operation bandwidth and more precise operation. A small-scale machine tool generally requires even higher stiffness than the ordinary large-scale machine tool since it is usually operated at higher speeds. Gantry style closed frame structure is chosen for our experimental setup which provides a strong rigid structure loop, symmetry, and good thermal stability, which provides better stiffness than the open frame structures generally used for easy access to the work zone, with the same order-of-magnitude in size.

**LAYOUT DIAGRAM**

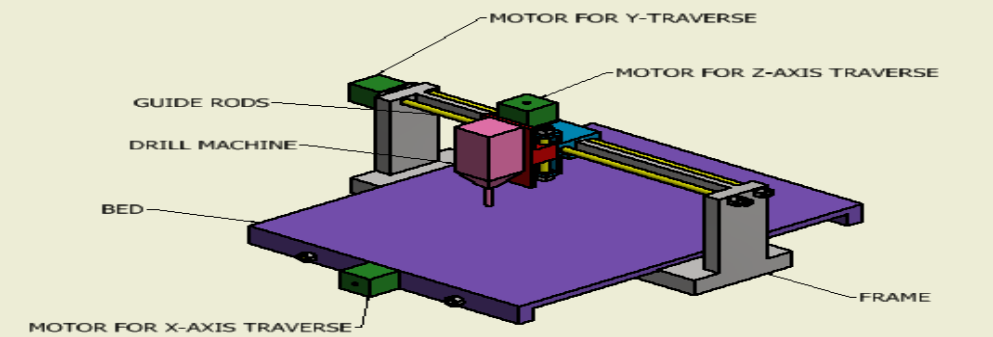


Figure 3.1 Initial Layout of Machine

The machines are designed with three movements coordinate X, Y and Z. Hole position consists of X, Y coordinates, and Z coordinate is a parameter to move the drill machines up and down. The drill is moved horizontally to X, Y coordinates of a hole, moved down in Z direction to make the hole, then withdrawn and translated to another place. Constructional features include:

### A. Fabrication of bed

The dimensions of bed are 600 x 500 mm. The bed was made of aluminium strips of 600 mm length and 20 mm thickness which were welded together at some finite distances by brazing. The aluminium strips were placed as shown in the figure below, and strips of same dimensions were placed along the length with spacing of 10mm between adjacent strips and were finally welded together as shown in figure 3.2.

Figure 3.2 Fabrication of Bed

### B. X-Axis Sub Assembly

Two rectangular aluminium plates with three holes each were fastened to the bed on both sides. The lead screw was passed through the centre hole. The other two holes were used for passing two guide rods. The two guide rods pass through the two holes in the base plate which is fixed. A nut is welded on the bed for the lead screw to pass through and move the bed as shown in figure 3.3.The motor is screwed to the motor support

plate which is in turn attached to the lead screw. The shaft of the motor has a radial hole which is used to couple the motor to the screw.

Figure 3.3 Fabricated Bed.

### C. Y-Axis Sub Assembly

The Y axis is similar in construction to the X axis sub assembly. The vertical frame has three holes, two for the guide rods and one for lead screw on which Z axis sub assembly setup is mounted as shown in figure 3.4.

Figure 3.4Y-Axis Sub Assembly

### D. Z-Axis Sub Assembly

The Z-axis assembly consisting of drill machine was constructed using three aluminium blocks which was joined together using two guide rods at the end and lead screw in the middle. The central aluminium block which is the nut has the drill machine assembly clamped to it. The drill machine is located and clamped to the PVC rectangular plate which is then bolted to the nut. This entire assembly is bolted to an aluminium plate on which four linear bearings are also mounted which slides over two horizontal guide rods. The Z- Axis Sub Assembly is shown in figure 3.5.

Figure 3.5 Z- Axis Sub Assembly

Figure 3.6 Final Assembly

## IV. Method

This paper demonstrates hardware and software implementation of a vertical drilling machine that is able to drill holes to designated places on the work piece. The system consists of a mechanical setup of that can move in X, Y and Z directions, a computer, a driving circuit and a software program. The driving circuit is developed to control the mechanical setup as well as to communicate with the computer. The software program is developed to control overall operation of the machine.

The operator first clamps the work piece on the machine bed. The drill machine is then brought to the origin which is fixed by the operator at the start of the drilling process. The operator then inputs the coordinates of the work piece with respect to the origin, in the graphical user interface which was prepared using visual basics software. The graphical user interface window is shown in figure 3.7.

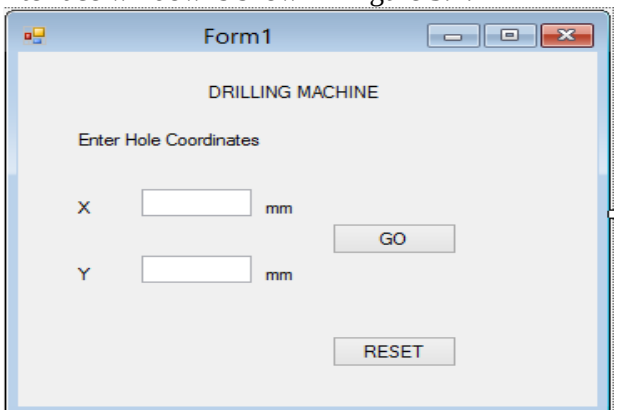


Figure 3.7 Graphical User Interface Window

After entering the required X & Y coordinates the operator presses the button ‘GO’ on the user interface window which will further move the tool to the required location and then drill a hole on the work piece. The maximum allowable hole diameter is 10mm, hence the drill machine is fixed at a certain distance from the work piece and bed thus providing a proper clearance between the drill bit and work piece.

## V. DRIVING CIRCUITRY

We have designed and developed a driving circuit given in the Figure3.7 in order to operate the drilling machine. The driving circuitry is developed using an Arduino Mega microcontroller. It controls and runs specific functions of the machine such as running stepper motors to move the machine in X, Y axis, running the drill and enabling or disabling an actuator that moves the drill up or down, it also communicates with computer port. The computer is used to perform specific tasks such as sending coordinates of steps which the stepper motor should move in accordance with the distance provided by the user. A L298 driver is connected to each stepper motor which receives pulse from microcontroller thereby rotating the motor to required steps. A program is written in Arduino software using simple C++ codes to achieve overall control of the machine and to perform data communication between computer and driving circuitry.

The user gives input from visual basics' user interface and a signal is given to Arduino mega microcontroller from where the signal transmitted to motor driver which drives the stepper motor which is attached to the mechanism. Rotary encoder is connected to motor to identify its position, if the position is not reached then a feedback signal is given to Arduino mega microcontroller to take the required action as shown in figure 3.8.

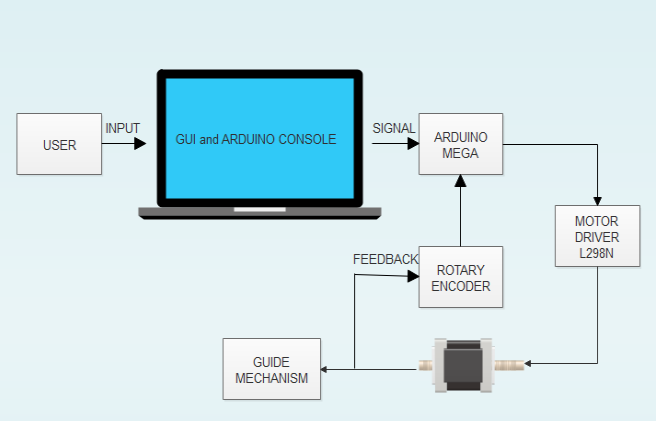


Figure 3.8 Block Diagram of Driving Circuitry

## VI. SOFTWARE DESCRIPTION

It was necessary to build the requisite software code which operates the hardware and computer elements. The movement of the motor was achieved by writing certain programs in the Arduino console window using simple C++ codes.

Following programming code runs Z-Axis stepper motor for certain revolution and ascertains it by rotary encoder feedback loop given to Arduino as shown in figure 3.9.

```
#include <Stepper.h>
#include <Encoder.h>
Encoder knobLeft(2,3);
const int stepsPerRevolution = 180; const int stepi = 1000;// change this to fit the number of steps per revolution
int a=0,b=3;
Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);
Stepper myStepper2(stepsPerRevolution, 30,31,32,33);
int incomingByte = 0;
String instring = "";
int StepPerRevolution(String strInput){
  int intStep;
  String strStep = "";
  int j;
  String strCmd;
  String strVal;

  for (int k=0; k<strInput.length();k++){
    strCmd = strInput.substring(k,k+1);
    if(strCmd=="X" || strCmd =="x"){
     while (k<strInput.length()){
      k++;
      strCmd=strInput.substring(k,k+1);
      if (strCmd!=" "){
        strStep+=strCmd;
      }else{
    break;
  }
```

Figure 3.9 Sample Code for Z Axis Traverse.

The same procedure was followed for the other two axis traverse, by writing an appropriate code and the results were successfully achieved.

## VII. DISCUSSION AND FUTURE WORK

The development of Automatic Wood drilling machine have been done. In its development, the cost incurred is very competitive and relatively cheap compared with the drilling machines available on the market. Several

tests must be conducted to adjust the appropriate parameters such as time delay or motor rotation speed for the optimal work. In our future works, we will continue to enhance different aspect of the drilling machine in order to have its function of hole drilling in a more economical and efficient manner.

## VIII. CONCLUSION

In this paper, the proposed Automatic wood drilling machine is equipped with three dimensional movements and considered to produce good precision accuracy for a competitive development cost comparing with another machine products manufactured by other companies which are not accurate, especially in drilling holes and with high cost material that is used in design. In this study, we have designed and developed a drilling machine that is able to follow the path prescribed by user and drill holes on a wooden planks. We have tested our system and showed that the automatic wood drilling machine successfully drilled holes on wooden planks.

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