Fabrication and Automation of Drilling Machine by Using Arduino

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Abstract. For precision workpiece manufacturing, the system should have good dimensional accuracy and surface finish. In applications such as drilling, punching, marking, boring, tapping, etc., the workpiece is first positioned, and then the tool executes its action while the moving axis remains stationary. In the traditional method of such applications, manufacturers use very expensive CNC machines to program the cycle and perform the same work. Large manufacturers can afford such expensive machines, but for the small machinery manufacturing industry, we must consider low-cost solutions that can provide high-quality output. In this study, we tried to propose a low-cost design that can be used to achieve functions similar to CNC. By applying this machine in industry, multiple generations can be obtained in a short time. It is very difficult to estimate the drilling depth when manually drilling with a traditional drilling machine, and the work will usually fail due to over-drilling. In many cases, it is difficult to measure the depth after the drilling is completed; especially the depth of the fine hole cannot be measured. Therefore, an automatic drilling machine that performs the drilling function according to the generated drilling depth and transmitted to the control circuit is indispensable; therefore, undertaking the study, it exposed the technology of the dedicated drilling machine. The automatic drilling machine designed here is very useful for the mechanical workshop. The machine is built with power feed technology and is designed to drill the job to a certain specified depth.

Keywords: Fabrication, automation, drill machine, manufacturing

1. Introduction

The drilling process is an important process in industry because it is used to drill holes in metal, wood, and other materials. The drilling machine uses a drilling tool with a cutting edge at its tip. The cutting tool is fixed in the drilling machine through the taper of the chuck (sleeve), and rotates at a constant speed and is fed into the workpiece. Drilling requires manpower, the depth of the hole cannot be estimated correctly, the work may be destroyed by human error, and holes of different sizes cannot
be drilled without replacing the drill bit. Repeatedly performing multiple tasks will consume a lot of time, these are disadvantages. In order to overcome all these problems, this automatic drilling machine is designed to automatically drill holes on the job according to the drilling depth data programmed through the keyboard. The main concept of this machine is to repeatedly drill holes in specific jobs at different depths, keeping the sequence. Since the machine contains a drilling motor, the motion control is accurate.

Mardane et al. [1] designed and manufactured an automatic attachment for positioning the drilling machine body according to the CAD model. A special accessory is provided to convert any drilling machine into an automatic drilling machine. With this attachment, the exact position of the working hole placed on the bed through its CAD model is achieved. In addition, Niranjan et al. [2] proposes a method to control mechanical movement by programming a microcontroller that will interface with the drilling depth feed motor. Seth et al. [3] carrying out such an arrangement on a radial drilling machine can reduce the time it takes to mark the center of the hole on the workpiece, and can avoid the need to use a microcontroller to make expensive and difficult-to-make fixtures. Alwis et al. [4], introduced the design of the PCB drilling machine, which eliminates the need to manually input the drilling coordinates and automatically detects the drilling in the circuit image. In addition, the machine uses a path planning algorithm that can estimate the effective travel path for the drill bit travel time. Jodh et al. [5] determined the design parameter considerations and configuration options, and they suggested that the gantry configuration is most suitable for better rigidity, precision and easy-to-program operation. Hong et al. [6] proposed a new multi-objective optimization method based on ant colony optimization (ACO). By expressing the efficiency and accuracy of riveting as a function of multi-degree-of-freedom point coordinates, a multi-objective optimization model for automatic drilling and riveting sequence planning is established. The time cost and accuracy of automatic drilling and riveting are described by point coordinates.

Automation is one of them, and many researchers have done a lot of research on it. The implementation of the automation system essentially eliminates the human aspect in the manufacturing process and brings many benefits. Automation will help move the drill to the desired drilling point, rather than the operator taking the time to move the drill to that point with sufficient accuracy. Automated production usually achieves higher consistency and accuracy in processing. In order to gain a competitive advantage in today's manufacturing market, a simplified manufacturing process approach is needed that focuses on increasing throughput while reducing or eliminating operator intervention. The most effective way to accomplish this task is through machine automation. Automation is the use of computers to control industrial machinery instead of manual operations. This is a step beyond mechanization. In mechanization, operators are provided with machines to help them complete their work.

2. Idea and Motivation

Manual drilling machines are the simplest and most common type of drilling machines in use today. These are light machines that are manually fed by the operator using the feed handle. In this way, the operator can "feel" the action of the cutting tool when cutting the workpiece. These drilling machines can be installed on a table or floor. They are driven by an electric motor that turns a drive belt on a motor pulley connected to the main shaft pulley. Manual feeders are essentially high-speed machines used in small workplaces that require holes of 1/2 inch or smaller. Usually, by loosening the locking bolt, the head can move up and down on the column. This allows the drilling machine to drill work at different heights. However, hand-delivered drilling rigs also have certain limitations. One of the most important issues is that a technician must always be present during operation on the machine. The operator's job is to provide manual feed to the drilling machine through the feed handle. There is also a torque limit when drilling larger holes. And because of the limited torque, the machine cannot handle harder materials.
All these limitations can be solved by using power feed drilling machines. Power feed drills are usually larger and heavier than manual feed. They can automatically feed the cutting tool into the workpiece at a pre-set cutting depth per spindle revolution, usually one thousandth of an inch per revolution. These machines are used in maintenance workshops for medium-sized work, or work with large drilling rigs that require electricity. Drill bits or cutting tools with diameters greater than 1/2 inch require power feed capability because they require more force to cut than provided by hand pressure. The speeds available on power feed machines can vary from about 50 RPM to about 1,800 RPM. The slower speed allows special operations such as counter bore, counter sinking, and reaming. These machines usually range in size from 17 inches to 22 inches with centre drilling capacity and are usually installed on the ground. They can handle drill bits up to 2 inches in diameter, which are installed in tapered Morse sockets. Larger workplaces usually use T-bolts and clamps to clamp directly on the workbench or base, while small workplaces are fixed with vice. There is a depth limiting device on the drill bit close to the spindle to help drill the hole to a precise depth. The use of power feed can solve many problems related to manual feed drilling machines. The main improvement is that there is a skilled operator who can "feel" the movement of the cutting tool when cutting the workpiece is no longer needed, because using the data acquisition system, the power feed drill can easily perform operations on a variety of different materials. Secondly, due to the introduction of the electric motor used to provide the feed, the problem of the large drilling force requirement that the manual feed drill cannot provide due to the limitation of the torque generated by the manpower is solved. In contrast, the electric motor can generate a huge amount of torque, enough to easily drill large-diameter holes.

3. Methodology

Through a brief study on the feed automation of the drilling machine, we have concluded that the electric motor used to power the drilling machine can be effectively controlled by using ARDUINO. After choosing the microcontroller, we must choose the motor according to our requirements. Our requirement is to control the vertical movement of the drilling rig. For this we need a motor with angular accuracy, speed control and torque required for operation. For these tasks, we can use servo motors as well as stepper motors.

Flow Chart of the System
3.1. Selection and Fabrication
There are different types of microcontrollers available, among which we have chosen Arduino as our microcontroller. It was chosen because of its low cost and convenient operation. Choose wood as the base material of the production device. The model was designed using Solid Works software version 20.0, and then manufactured as shown in Figure 1. The material of choice for our model manufacturing is plywood. We chose this material because it provides enough strength for our model and it is easily available in the market at a reasonable price.

![Fabricated experimental model](image)

Figure 1 Fabricated experimental model

3.2. Programming for Angular Control
```cpp
// defines pins numbers
const int stepPin = 5;
const int dirPin = 2;
const int enPin = 8;

// Button
const int b1 = A0;
const int b2 = A1;
const int b3 = A2;
const int b4 = A3;
int currentAngle = 0;
int angle = 0;
float stepPerAngle = 1.8; // full step = 1.8
int numstep;

void setup() {
  Serial.begin(9600);
  // Sets the two pins as Outputs
  pinMode(stepPin,OUTPUT);
  pinMode(dirPin,OUTPUT);
  pinMode(enPin,OUTPUT);
  digitalWrite(enPin,LOW);
  digitalWrite(dirPin,HIGH);
  pinMode(b1, INPUT);
  pinMode(b2, INPUT);
  pinMode(b3, INPUT);
  pinMode(b4, INPUT);
}

void loop() {
  int n;
```
if( digitalRead(b1) == HIGH){
    angle = 0;
} else if( digitalRead(b2) == HIGH){
    angle = 45;
} else if( digitalRead(b3) == HIGH){
    angle = 225;
} else if( digitalRead(b4) == HIGH){
    angle = 270;
}

if( currentAngle != angle ){
    if( currentAngle < angle){
        digitalWrite(dirPin,HIGH);
        n = angle - currentAngle;
        numstep = n / stepPerAngle;
    } else if( currentAngle > angle){
        digitalWrite(dirPin,LOW);
        n = currentAngle - angle;
        if( angle == 0){
            n = currentAngle;
        }
        numstep = n / stepPerAngle;
    }
    for(int x = 0; x < numstep; x++) {
        digitalWrite(stepPin,HIGH);
        delayMicroseconds(1000);
        digitalWrite(stepPin,LOW);
        delayMicroseconds(1000);
    }
    currentAngle = angle;
} delay(500);

4. Results and Discussion
We can see that all the production based industries wanted low production cost and high work rate which is possible through the utilization of multi-function operating machine which will less power as well as less time, since this machine provides working at different center it really reduced the time consumption up to appreciable limit. This project is a combined effort and the goal was to produce a cost effective drilling machine which would help the small scale industry. It would help to drill holes easily at any desired depth. Using small machine tools to fabricate small scale parts can provide both flexibility and efficiency in manufacturing approaches and reduce capital cost, which is beneficial for small business. Arduino based drilling machine is designed and implemented under very limited budget. From this paper, we can get a machine which has high accuracy and low cost as compared to large CNC machine.

4.1. Practical Implementation
   a. Can be used very efficiently in small scale Industries.
b. Affordable and can be manufactured very easily.

c. Reduces labour cost as single computer can be used to control many drilling machines.

d. Increases product quality because human errors are eliminated.

4.2. Industrial Application

a. It is primarily utilized for holes of precise depths and various dimensions, on a variety of surfaces.

b. It is featured of performing a variety of tasks like tapping, spot facing, reaming, counter sinking and counter boring etc.

c. Precise drilling is always required for a vast number of manufacturing processes that are related to different types of metals.

d. It is also considered as one of the multi-purpose equipment’s; as it also has the skill to execute a number of functions.

e. It normally utilizes one or the other type of drill bit to drill very precise holes in a specific material. Besides this, it can also be utilized for bonding two pieces of materials together with the help of some kind of fastener.

f. When the tool is utilized for placing fasteners; it simultaneously drills holes that are extremely precise, through the work piece while installing the fastener.

g. Accessible in a variety of specifications, and can also be supplied as per the customized needs of the clients in the national as well as international markets. As a result, there is a huge demand throughout the world.

5. Conclusion

The method proposed in this study needs to be further improved for accurate machine in drilling operation. On large size drilling, for example in the case of PCB drilling operations, the proposed model may not be possible and provides the best solution. In addition, the joint effort and goal was to develop a cost-effective drilling machine that would help small-scale industry. The Arduino based drilling machine is designed and implemented on a very limited budget.

Conflict of interest
None.

References

[1] R. Mardane, U. Gulhane and A. Sahuis, "Design and fabrication of automated attachment for positioning bed of drilling machine with respect to cad model," *IJARIE*, vol. 2, no. 4, pp. 95-100, 2016.

[2] G. Niranjan, A. Chandini and P. Mamatha, "Automated Drilling Machine with Depth Controllability," *International Journal of Science and Engineering Applications*, vol. 2, no. 4, pp. 90-93, 2013.

[3] K. Barad, M. Balsara, G. Patel and S. Sheth, "Automation of conventional radial drilling machine," in *innovations in Mechatronics Engineering*, 2009.
[4] P. Alwis, A. Premarathna, Y. Fonseka, S. Samarasinghe and J. Wijayakulasooriya, "Automated printed circuit board (PCB) drilling machine with efficient path planning," in *SAITM Research Symposium on Engineering Advancements*, 2014.

[5] G. Jodh, P. Sirsat, N. Kakde and S. Lutade, "Design of low Cost CNC Drilling Machine," *International Journal of Engineering Research and General Science*, vol. 2, no. 2, pp. 189-196, 2014.

[6] X. Hong, L. Yuan, Z. Kaifu, Y. Jianfeng, L. Zhenxing and S. Jianbin, "Multi-objective Optimization Method for Automatic Drilling and Riveting Sequence Planning," *Chinese Journal of Aeronautics*, vol. 23, no. 6, pp. 734-742, 2010.