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Automated Drilling Machine Based on PLC

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Abstract

This paper aimed to design and fabricate an automated drilling machine based on PLC to produce holes (8mm depth) in the center of a cubic work pieces (3 cm ×2 cm × 3cm). The drilling machining process proposed for a cycle of drilling. The cycle process is start when the start switch is pressed; the linear motor is put in place the drilling head in home position, and rotate the rotary disk to bring the first work pieces to desired position. Meanwhile, the drilling process is running after the inductive sensor in the (desired position) sense the object. Then the process will stop automatically when made the hole and went back to the home position, after that the rotary disk start to rotate quarter cycle to carry the drilled object out the table during the lower rotary disk. The PLC used to perform these operations, by reading data from sensors and actuate the DC motors. At the end of this project, the result shows that the designed system was able to run the drilling process autonomously for three object per minute based on the desired sequence.

Keywords: *Drilling Machine, Automated, PLC, Switches, Inductive Sensor, Limit Switches.*

1. Introduction

The drilling process is an important process in industries because it is used to made holes into or through metal, wood, or other materials. Drilling machines use a drilling tool that has cutting edges at its point. This cutting tool is held in the drill machine by a chuck (quill) taper and is rotated and fed into the work pieces at constant speeds. Drilling machines may be used to perform other operations. They can perform countersinking, boring, counter boring, spot facing, reaming, and tapping, drilling machine is the most common machining process in industries. Control engineering is one of the aspects, which have been given a great deal by many researchers. It became to a great concerns in many areas such as industry, agriculture, medicine, education and infrastructure. Automatic control system have emerged as an integrated part in telecommunication, electricity, and other application. This project is devoted to the use of control system in drilling system; the control system will play a major role in control on all parts of the project as shown in Figure 1.

Initially, when start switch (toggle switch) is pressed, the linear motor is moving up until reach the home position. Then the rotary disk starts to bring the work piece until it reaches a certain position, which is felt by the inductive sensor, after that the linear motor is work down and then after a certain time starts drilling motor to drill the work piece to a certain depth and finally disposed of the work piece and bring another.

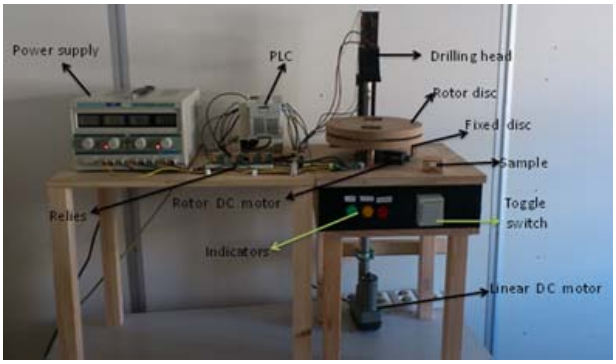

Fig. 1 Drilling System Prototype.

2. System Components and Hardware Structure

The automated drilling machine system consists of four important stages as shown in Figure 2. These stages are:

- The first stage consists the sensors and switches (input devices) those feed the controller by some information about the machine situations.
- The second stage is the controller, which is the brain of the system, which get information from sensors and take the decision before send the orders to the output devices by actuators.
- The third stage is the actuators and indicators of the drilling machine (output devices), which get orders from the controller.
- The fourth stage is the mechanical structure and design of drilling machine process.

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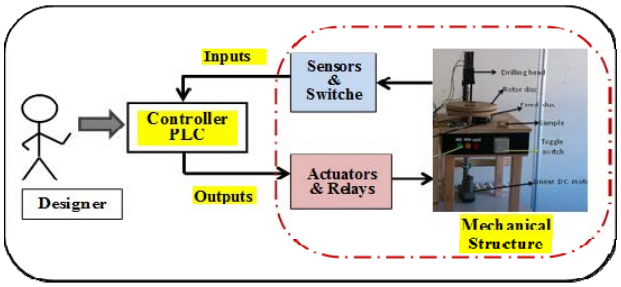

Fig. 2 Automated Drilling Machine System

2.1Sensors

Sensors are very important devices in industrial control system, which translate a physical phenomenon into an acceptable signal that can be analyzed. They can be used during pre-process, in-process and post-process operations. Sensors also can be divided into two types:

- Contact type.
- Non-contact type such as proximity sensors [2, 3].

2.1.1 Proximity Sensor

Proximity sensor is electronic device, non-contact type used to detect an absence or presence an object. Proximity sensors come of two types, *inductive proximity* sensor and *capacitive proximity* sensor.

Inductive proximity sensor are able to detect and sense nearby metallic objects without any physical contact within range 1-7 mm. Otherwise, capacitive sensor are used to detect metallic and non-metallic objects without direct contact [3, 7].

2.1.1.1 Inductive Proximity Sensors

Inductive sensors use currents induced by magnetic fields to detect nearby metal objects. All of inductive sensors consists of four basic elements; the *oscillator*, which produces the electromagnetic field, the *coil*, which generates the magnetic field, the *detection circuit*, which detects changes in the field when an object enters it and the *output circuit* which produces the output signal [4]. The sensor was installed during the lower rotary disk in order to sense the object when reach the desired position as shown in Figure 3.

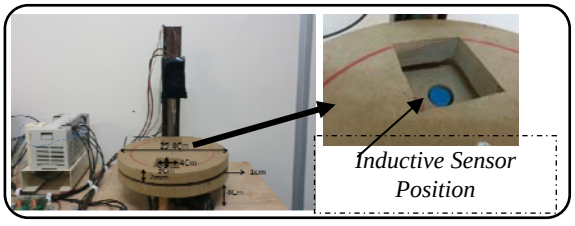

Fig. 3 Inductive Sensor Setup on the Project

In the prototype, the inductive sensor installed in the lower disk, inside a hole in order to sense the work piece before the operation start. The lower and upper disk thickness is 2cm, and the diameter of each 25.4cm. with gap between the upper and lower disk about (1cm).

2.2 Switches

Switches are electrical or electronic contact devices used to turn (ON) or (OFF) the flow of electricity through a circuit. Switches are essential components in almost all the electronic devices used today. Switches require another device or action (Force) to change their state from open to close or close to open. Switches might operate manually or mechanically.

- Manually Operated referred to types operated by hand, which the operator must do an action, in order to start, stop or reverse the state. Manually switches such as (***toggle and pushbutton switches***).
- Mechanically Operated referred to switches those controlled automatically (Mechanically) by factors such as pressure, position, flow, or temperature. These include (***limit switch, inductive limit switch***) [5, 6].

2.2.1 Limit Switch

The limit switch is one of the main of switches used in automatic control. The limit switch has a set of connecting points. In the event these points are collided with anything, their positions will be changed .when the situation of the connecting points is changed, the limit switch operates or intercepts the running load (such as an engine) or issues an alert and etc. The limit switch as shown in the Figure 4.

Fig. 4 Limit Switch Used

2.2.1.1. Position of Limit Switch in Project

As shown below in Figure 5, two limit switches are installed in the project, named X1, X2 on the vertical rod. The upper limit switch (X1) is used to put the system at home position and start drilling cycle by run the rotary disk to bring the object to the desired position. The lower limit switch (X2) is used to:

- Stop the motion down of linear motor.
- Drill (8mm) inside the object.
- Move the linear motor up to home position.

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- Rotate the rotary disk quarter cycle to push out the finished object.

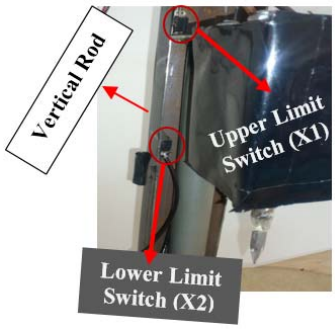

Fig. 5 Limit Switches Setup on the Project

2.2.2 Toggle Switch

A manually operated switch is on that is controlled by hand. A single pole single throw toggle switch connects or disconnects one terminal either to or from another. It is the simplest switches. Figure 6 below is an example of manually switches used in the project.

Fig. 6 Project Toggle Switch

2.3 Actuators

Actuation defines as the result of a direct physical action on the process, such as drilling a work piece or rotate the object from side to another side by rotating the upper rotary disk.

2.3.1 DC Motor

DC motors have been used in industrial applications for years. Coupled with a DC drive, DC motors provide very precise control. DC motors can be used with conveyors, elevators, extruders, marine applications, material handling, paper, plastics, rubber, steel, and textile applications. In this prototype project, we used three DC motors for different movement as shown in Figure 7.
Rotary DC motor to rotate the upper rotary disk.
Rotary DC motor to rotate the spindle to drill the object.
Linear DC motor to move up and down the vertical rod, which handle the drilling head [1, 8].

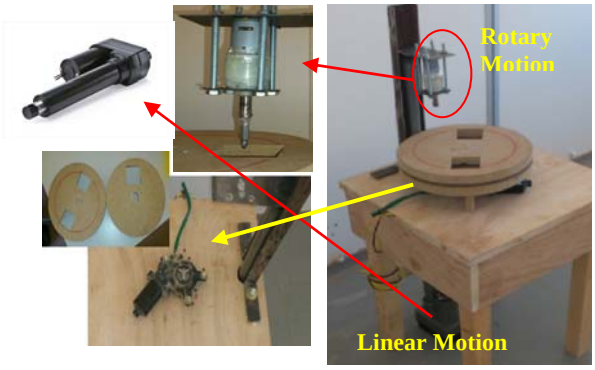

Fig. 7 DC Motors with Rotor and Linear Actuator.

2.4 Relays

Relays are simple switches operated both electrically and mechanically . Relays consists of an electromagnet and set of contacts .There are also other operating principles for its working which differ according to their applications, Figure 8 shows type of electro-mecanical relays used in the project [1].

Fig. 8 Type of Relays.

2.5 Indicators

Indicators are used to monitor the operation or condition and the telecommunication and electrical circuit for indicator signal, accident signal, fault signal and other indicator signals.
In our project as shown in Figure 9,we have chosen three types of indicators in order to monitor different operations, this indicators are:

- *Green indicator*: To show that, system working state.
- *Read indicator*: To indicate drilling motor operation.
- *Yalow indicator*: To indicate rotary disk operation.

Fig. 9 Indicators.

ISSN 2348 – 7968

2.6 Mechanical Structure and Design

The project table dimension is 40cm × 40cm × 50cm (length x width x height). On This table, a window DC motor mounted to rotate the rotary disk, and DC linear motor holding the drilling head and quill with spindle as shown in Figure 7 and Figure 10.

The drilling head: Is the mechanism used to revolve the cutting tool (spindle) by DC motor.

Quill: house of the spindle.

Spindle: round shaft holds cutting tool.

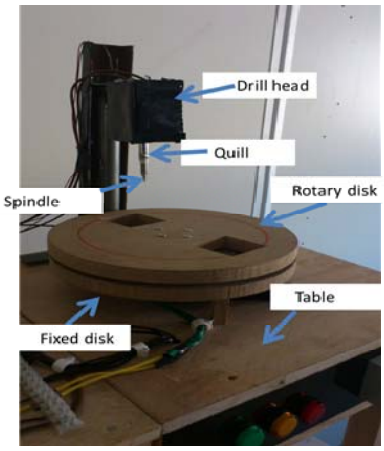

Fig. 10 Mechanical Strictures of the project

2.6.1 Fixed and Rotary Disk

The project consist of two circular disk rotary and fixed as shown in Figure 11.

- ***Fixed disk***: Its dimension 25.4 cm diameter and 2 cm thickness, with square hole 4cm x 3cm used to drop the finished work piece, this disk is mounted over the rotary DC motor during small hole.
- ***Rotary disk***: Its dimension 25.4 with two square hole 3cm x 2cm.this upper disk is mounted with the DC motor. The square holes were used to bring work pieces to the position and drop finished work pieces with lower disk.

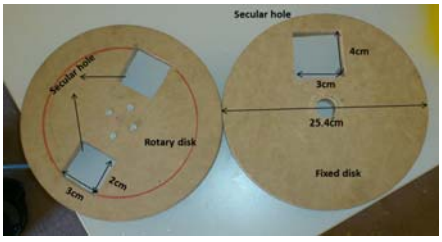

Fig. 11 Fixed and Rotary Disk

3. System Wiring and Implementation

Figure 12 shows the connection of each part that has been used in this project, these parts are:

- ***Toggle switch***: Tow wires in this switch connected to the PLC one of these wire connected to the 24V DC, the other wire connected to the input of the PLC (**X0**).
- ***Upper limit switch***: Tow wires in this switch connected to the PLC one of these wire connected to the 24V DC, the other wire connected to the input of the PLC (**X1**).
- ***Lower limit switch***: Tow wires in this switch connected to the PLC one of these wire connected to the 24V DC, the other wire connected to the input of the PLC (**X2**).
- ***Inductive sensor***: Three wires in this sensor connected to the PLC tow wire is to feed the sensor, first wire connected to the 24V DC, the second wire connected to the 0V, the other wire connected to the input of the PLC (**X3**).
- ***Linear dc motor***: Since the motor is 30V DC and the PLC is 24V DC, the 24V DC mechanical rely is used, we are used tow mechanical rely to reverse the direction of rotation of the motor, connected the NO of tow relies to gather and NC to gather. The motor was connected to the output of the PLC (**Y1**) for up motor and PLC (**Y2**) for down motor.
- ***Drill motor***: since the motor is 5V DC and the PLC is 24V DC, the 24V DC mechanical rely is used. The motor is connected to the output of the PLC (**Y4**).
- ***Rotary motor***: since the motor is 2.1V DC and the PLC is 24V DC, the 24V DC mechanical rely is used. The motor is connected to the output of the PLC (**Y3**).

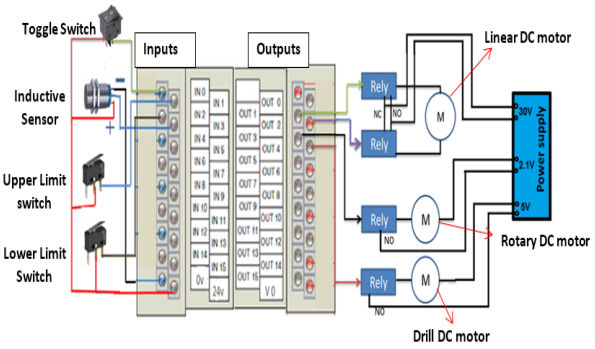

Fig. 12 Drilling System Wiring Diagram.

3.1 Programmable Logic Controllers (PLC)

Technical specifications of PLC Mitsubishi FX2n-32MT on the Table 1 [8].

Table 1: Technical Specifications of Mitsubishi PLC

ISSN 2348 – 7968

General features	
Max .number inputs/outputs	16
Power supply	100-240 VAC
Output type	Transistor
Power consumption [W]	30 V A
Weight [Kg]	0.65
Dimensions (WxHxD) [mm]	136x90x87

4. RESULTS AND DISCUSSIONS

Tasks of the drilling system component are:

***Toggle switch*:** is main switch to start up the system and turn off the system.

***Mechanical rely*:** is used to appropriate between the motors and PLC.

***Linear motor*:** is used to move up and down the drill head.

***Drill motor*:** is used to rotor the spindle to drilling the work pieces.

***Rotor motor*:** is used to rotor the upper disk for bring work pieces.

***Inductive sensor*:** is used to detect the presence of the sample at the desired position.

***Indicators*:** are used to light different colors to show system states.

***Limit switches*:** are used to stop the linear motor upper and down motion.

The prototype of the automated drilling system was built by combining the mechanical design and electrical design as shown in Figure 1 above.

Initially, when the toggle switch is pressed ON, the green indicator is turn (ON) to show system running, the DC linear motor is moving up to put in place the drilling motor(Drilling Head) in home position, at the upper limit switch (X1) as shown in the Figure 13.

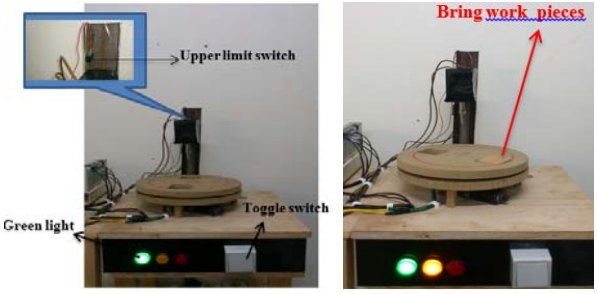

Fig. 13 System Starting.

As the work pieces reach the desired position (over the proximity sensor) the rotor disk stop rotating, and yellow indicators turn OFF, after that the second stage start running by moving down DC linear motor, and for certain time about 7 seconds the drilling motor turn 0N till the work pieces drilled about (8mm). with this operation the read indicator turns ON, see Figure 14.

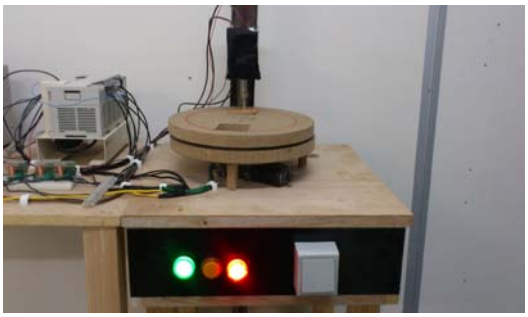

Fig. 14 Drilling Operation.

System start drilling the work piece until the lower limit switch activate, then the system stop drilling and the up linear DC motor activate to put the drill head at home position.

Finally, new work piece feeded to empty square hole, and the rotary uper disk start to rotat quarter cycle to push out the drilled work piece during the lower disk hole as show below in Figure 15.

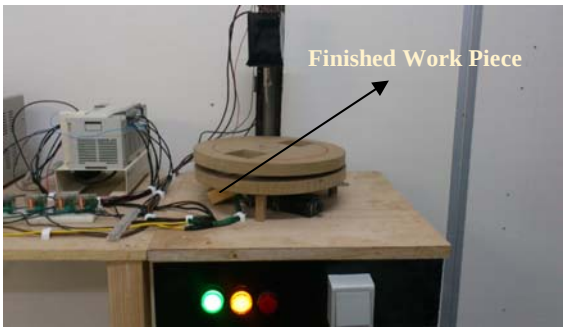

Fig. 15 First Object drilled.

5. Conclusion

In conclusion, the automated drilling machine was successfully designed and implemented based on PLC control system. The prototype is done to drill a small hole in wood work-piece about (8mm) in depth, and perform drilling for 3 objects per minute, in order to increase the efficiency of small drilling machines instead human work. From the results of drilling performance testes, the system was apple to drill small holes and all the objectives were done successfully as proposed.

ISSN 2348 – 7968

6. References

[1] A. Albagul, K. Alsharef, M. Saad, Y. Abujeela, "Design and Fabrication of an Automated Multi-level Car Parking System", in Manufacturing Engineering, Automatic Control and Robotics, 2013.
[2] S. K., Robotics, McGraw-Hill, 2008.
[3] D. Shetty and R. Kolk, Mechatronics System Design.India, 2004.
[4] Hugh Jack, Automating Manufacturing system with PLC, version5.New York, 2007.
[5] Allan R. Hambley, Electrical Engineering Principles and Applications. Pearson Education Limited, 2013.
[6] Himanshu Mishra, PLC BASICS COURSE , Schneider Electric. India New Delhi.
[7] S. k. Bhattacharya, Industrial Electronics and Control,Delhi,2006.
[8] Khalid. A.alsudany, multi-level car parking system, College of Electronic Technology, Bani Walid, Libya, B.Sc. project, 2012.

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