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Modification of Conventional Drilling Machine into Automated Drilling Machine Using Plc

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ABSTRACT: The main aim of this research paper is to modify a conventional drilling machine into an automated drilling machine using PLC to increase the production rate and accuracy of the process.

As the conventional method may lead to error in accuracy, an increase in manufacturing lead time creates fatigue of operators, manual error, we move towards the automated process. The automated process in drilling is aided by PLC. The component is mounted on the fixture and the start button is pressed. Once the drilling process is completed, the machine automatically stops. The sequence of operations and inter-relation between the drilling machine, rotary indexer, and coolant flow is controlled by the PLC. The limit switches are provided to sense the completion of the operation and send signals to the PLC to complete the sequence of operations. Provision for emergency stop of the process is also provided.

Therefore the automated drilling machine overcomes the disadvantages of the conventional process.The cost of this machine is lower and hence it can be used by small scale industries.

KEYWORDS: Drillingmachine,PLC, Limit switch, Rotary indexer, Solenoid coil.

I. INTRODUCTION

In this paper, acircular component is consideredby drillingholes on its outer periphery. A bench-type drilling machine is used for drilling the holes and a jig is used to position the location at which the holes need to be drilled on the component. The jigs arecircular as like the component with multiple holes, which acts as a reference to the position to be drilled. Hence, an employee needs to position the component on the jig and make a hole through the reference point. After that, the jig is rotated manually by the employee and the next hole is produced. This series of operation is done until the required number of holes are made.

The industry follows manual drilling, which in turn increases the manufacturing lead time (MLT). It also leads to fatigue of employees. In the case of manual drilling, the accuracy and precision of the production process may also be reduced. This may also lead to manual error and damage to the components. To overcome this problem, the drilling process can be automated. Then the project is been overviewed with several literature reviews to overcome the problems faced in the fabrication process.

In this project, a conventional drilling machine is modified and made as an automated drilling machine. The automation is achieved by using the Programmable Logic Controller (PLC). The automated drilling machine uses a conventional bench-type drilling machine whose spindle rotation is driven by a motor and feed of the drill bit is controlled by a hydraulicpiston-cylinder arrangement.

The component is mounted on a fixture, which is attached to a rotary indexer. The rotary indexer is driven by a stepper motor. The stepper motor when energized can position the component to accurate and precise positions. The coolant is also used to remove the burr, chip formation and to increase the tool life.

The limit switch plays a major role to control the sequence of operations. It senses the completion of a cycle and sends the information to the PLC in order to actuate the next cycle. Provision for emergency stop of the process is also provided.

The main objective of this project is to modify a conventional drilling machine into an automated drilling machine based on PLC to position the job and up and down motion of the drilling machine to produce holes, in order to increase the accuracy, increase the production rate,

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reduce the manufacturing lead time, reduce the fatigue of workers.It can be used in industries for drilling purposes. Cost is lower and hence can also be used in small scale industry.

II.CONVENTIONAL DRILLING MACHINE

The drilling machine is one of the simplest, moderate,and accurate machine tools used in the production shop and tool room. It consists of a spindle which imparts rotation to the drilling tool.since its chief function is to make holes, it is considered as a single purpose machine tool

It can andperform operations other than drilling also. Here we use a bench-type drilling machine. The specifications of the drilling machine are shown in table 1.

Table 1 Specification of Drilling Machine

Make	WINDSON
Drilling Capacity	3-33mm
Maximum workpiece size	620mm
Stroke length	200mm
Leg size	500mm x 320mm
Bed size	300mm x 300mm
Motor capacity	1HP

III. MODIFIED AUTOMATED DRILLING MACHINE

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The coolant is also used in order to remove the burr, chip formation and to increase the tool life. The limit switch plays a major role to control the sequence of operations. It senses the completion of a cycle and sends the information to the PLC in order to actuate the next cycle. Provision for emergency stop of the process is also provided. The picture of the completed model is shown in figure

The pillar drilling machine before modification is shown in figure 1.

Figure1. Conventional Pillar type drilling machine

Figure 2. AUTOMATED DRILLING MACHINE

IV. CONCEPTUAL DESIGN AND CALCULATION

The broad view of this chapter is to provide the significance of materials, fabrication process and its methods, Design and Design calculation, Electrical and control methods used in this equipment.

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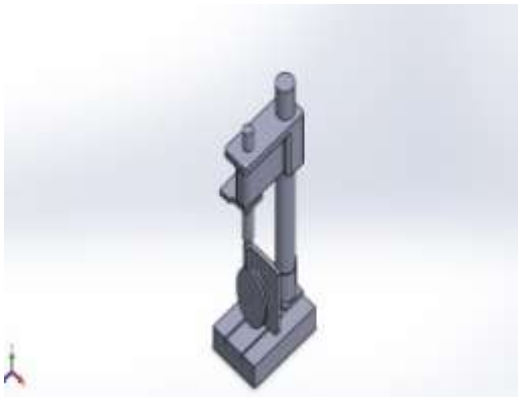

Figure 3 CONCEPTUAL DESIGN

The complete design of all components in the machine is done in solid works. As per the requirements and operating conditions of the machine, material and equipment selection is done for all components. The machining methods such as Gas cutting and Welding is done for plates. Machining operations like turning, drilling, milling is done to obtain the plates of required dimensions. Equipment like hydraulic cylinders and spindle of the drilling machine is supported using the plates.

DESIGN CALCULATION

Cutting speed of the tool

Component material = EN8 (C45)
Tool material = HSS
The hardness of HSS = 277 HRB
Cutting speed, μ $= \frac{\pi DN}{1000}$
Where,
μ= Cutting speed in m/min
D = Diameter of the tool in mm
N = Speed of the tool in rpm
The diameter of the tool, D = 3mm

From PSG DB Pg no.12.10 w.r.t hardness =277HRB for C45

μ=25 m/min

$25 = \frac{(\pi \times 3 \times N)}{1000}$

N = 2654 rpm

N ≅ 2700 rpm

Power of the drilling machine motor

From PSG DB Pg no. 12.1,

$P = 2.82 \times 10^{-6} \times K \times n \times z \ (D^2 - d^2) \ (0.15 + 7.87S)$

Where,
K = Material factor
n = Speed in rpm
z = Number of cutting edges in contact
S = Feed/Blade/Revolution in mm

From PSG DB Pg no. 12.2 w.r.t Carbon steel BHN = 277,
K = 3.44
Number of cutting edges in contact,
z = 2
From PSG DB Pg no. 12.10 w.r.t carbon steel BHN = 277,
S = 0.025 mm
D = 3 mm

$P = 2.82 \times 10^{-6} \times 3.44 \times 2700 \times 2 \times 3^2 \times (0.15 + (7.87 \times 0.025))$

P = 0.163 kW

P = 0.3 HP (1 kW = 1.36 HP)

It is recommended to use motor with high power, so motor with **1HP** power is chosen.

The torque of the drilling machine

$P = \frac{2\pi NT}{60}$

$0.163 \times 10^3 = \frac{2\pi \times 2700 \times T}{60}$

T = 0.58 Nm

Axial thrust of hydraulic cylinder

From PSG DB Pg no. 12.1

Axial thrust $= 630 \ K \ z \ (D\text{-}d) \ S^{0.85}$

$= 630 \times 3.44 \times 2 \times 3 \times 0.025^{0.85}$

Axial thrust = 565.33 N

System pressure to select hydraulic cylinder

$P = \frac{F}{A}$

Where,
P = System pressure in N/m^2
F = Axial Thrust in N
A = Area of cylinder in m^2

To find cylinder diameter,

$P = 15 \times 10^5 \ N/m^2$

(The recommended pressure in open system is 15bar)

$15 \times 10^5 = \frac{565.33}{\frac{\pi}{4}d^2}$

d = 0.054 m

d = 54 mm

Standard cylinder diameter = 63 mm

Standard stroke length of 63 mm diameter cylinder,

L = 300 mm

Standard piston rod diameter,

d_p = 35 mm

Selection of hydraulic motor

$P = \frac{Pr \times lpm}{600}$

Where,

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P = Power of hydraulic motor in kW
Pr = Pressure of system in bar
lpm = Discharge in lit/min

$$P = \frac{15 \times 5}{600}$$

P = 0.125 kW

It is recommended to use motor with high power, so motor with **0.75kW** power is chosen.

V. OBSERVATIONS FROM THE TESTS CONDUCTED

Time consumption for 12 holes

The automated drilling machine is tested for 12 number of holes under various indexing speeds of a stepper motor. The feed rate of the tool is set at optimum condition for obtaining the best surface finish and kept constant for all the conditions. The constant feed rate is set at 2.74 mm/s. Theangle between two consecutive holes is 30.

The comparison of time taken for producing 12 holes with varying indexer speeds is shown in table 2.

Table 2 Comparison of cycle time for 12 holes.

Indexing speed for 12 holes	Total time in seconds
8000 rpm	206.4
10000 rpm	202.8
12000 rpm	200.52
13000 rpm	199.08

VI. CONCLUSION

To modify the conventional drilling machine into an automated drilling machine the conceptual design of the automated drilling machine is first drawn using solid works to get an outline of the model. Design calculations are made for selecting the required components that would be suitable for the required operation. Then the required components are purchased economically. All the required modifications are made to the procured components using various machining operations. Then assembly operations are carried out. Assembling is either done by welding operations or by using fasteners of suitable size. Then PLC programming is done to carry out the required operations in a sequential manner. Testing is done in order to confirm the ideal working of the automated drilling machine.
machine is way ahead than the manual methods.

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