

Design and Fabrication of Automatic Glass Cutting Machine

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Abstract: This paper deals with the design and fabrication of the automatic glass or mirror cutting machine. In order to increase the accuracy of cut and production rate; and decrease the production time and accidents caused due to manual cutting of mirror or glass, this project aims at development of an automatic machine which uses a programmable logic controller (PLC) for controlling the movement of the conveyer and also to control the pneumatic circuit. In this machine, the work of the operator is to load and unload the mirror. The cutter used in this machine is carbide wheel with its cutting edge ground to a V-shaped profile. The PLC controls the pneumatic cylinder and intern actuates the cutter along the glass, a fracture layer is formed causing a mark to be formed below the fracture layer and a crack to be formed below the rib mark. The machine elements are designed using CATIA V5R20 and pneumatic circuit are designed using FESTO FLUID SIM software.

Key words: PLC, pneumatic, servomotor, conveyor.

1.Introduction:

Mirrors are produced by applying a reflective coating to an appropriate substrate. The most well-known substrate is glass, because of properties like transparency, ease of fabrication, rigidity, hardness, and ability to take a smooth finish. Normally the back surface of the glass is coated with the reflective surface, so that the reflecting surface of the coating is shielded from being corroded and accidental damages.

The most commonly used reflective coating for glass mirrors are:

1. Tin(II) chloride
2. Silver or aluminium
3. Copper



1.1 Automation

Automation^[6] is the technology by which a process or procedure is accomplished without human assistance. It is implemented using a set of instructions combined with a control system that executes the instructions, to automate a process power is required, both to drive the process itself and to operate the program and control system. Although automation can be applied in a wide variety of areas, it is most commonly associated with the manufacturing industries. It was in the context of manufacturing that the term was originally coined by an engineering manager at Ford Motor Company in 1946 to describe the variety of automatic transfer devices and feed mechanisms that had been installed in Ford's production plants. It is ironic that nearly all modern applications of automation are controlled by computer technologies.

Types of Automation

Automated manufacturing systems can be classified into three basic types

- (1) Fixed automation. (2) Programmable automation (3) Flexible automation

Fixed automation: Fixed automation refers to the use of custom-engineered (special purpose) equipment to automate a fixed sequence of processing or assembly operations. This is also called hard automation. The main drawbacks are the huge initial investment in equipment and the relative inflexibility. This project is basically a fixed type of automation where the sequence of process is fixed for cutting of glass only.

1.2 Programmable logical controller (PLC)

Manufacturing^[1] process were somewhat automated by the utilization of control circuits, electrical, hydraulic and pneumatic. Whenever there is a change in process, the whole system need to be reconfigured. In order to overcome this problem, microcomputers were developed. Due to this development, it was found that if the process has changed the system need not to be get rewired and simply the changes could be made by reprogramming the computer and so the PLC was developed. PLC is a type of automation tool in which a digitally operating electronic system which uses a programming memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analog modules, various types of machines or process. The main advantage of PLC is that, based on the application, the input and output can be mixed.

Advantages of PLC

- Less Maintenance and easy to detect faults in system.
- It can communicate with other PLC devices or different computers.
- Instant monitoring system.
- Low cost and Durability

Conveyors are durable and reliable components used in automated material handling process. with the integration of computer controller and the conveyer, it results in increase in manufacturing. Belt conveyor automation will increase the control characteristics of conveyor in real time without requiring physical man power and efficiency of belt conveyor. These are the nylon rubber belts which move on the nylon gear.

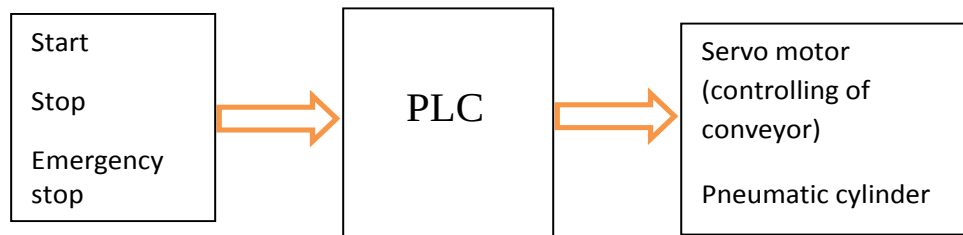


Figure:1 The block diagram of the PLC system.

Current method of cutting:

- **Manual Scribing and breaking:** It is method used to cut the glass, where the thickness of the glass is constrained to 2mm. the procedure for this type of method is, Marking the line on glass or mirror by scribe as shown in fig. 2 with a tungsten carbide tool at its end. Place a straight edge along the scribed line and use it as a guide for the scribe or knife. Scribe the mirror along the line by repeating the scribing process with an evenly pressure. Then break the mirror with a downward pressure.



Figure 2. Scribe used in manual cutting of glass

This project involves the automation of the scribing and braking method which can be achieved with the help of PLC by controlling the pneumatic valves and servo motor.

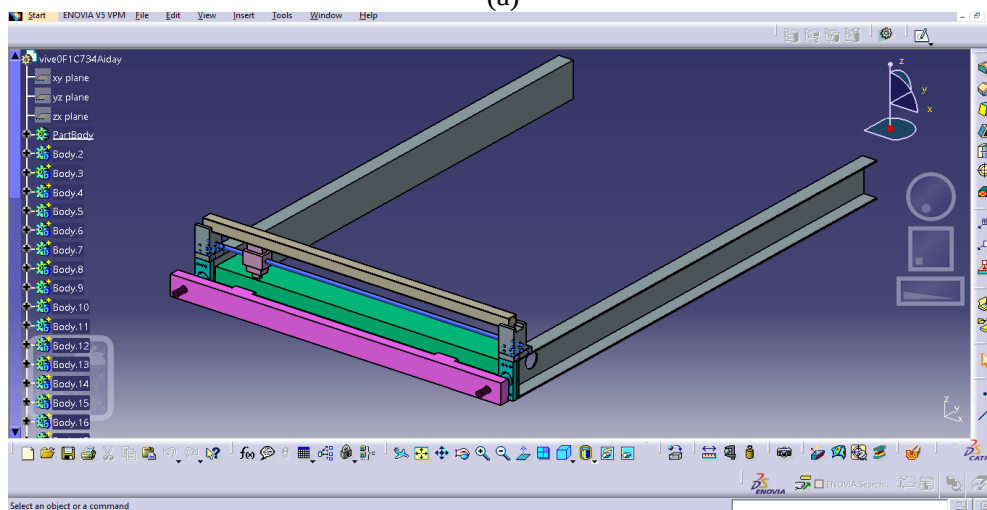
2. Methodology:

- Extensive study is carried out to understand the design of glass cutting machine elements.
- Design of glass cutting machine is carried out using CATIA V5 R20.
- Pneumatic circuit design is carried out using FESTO Fluid SIM software.
- Simulate the model to study the glass cutting process.
- Fabricate the model by selecting suitable materials.
- Modify the design if there are any defects.

3. Proposed design:



(a)



(b)

Figure 3: shows (a) An assembled view of the machine and (b) view of a cutting tool.

The above figures shows the design of the machine elements by using CATIA modelling software.

4. Construction components:

4.1 Bed:

It is made up of mild steel (M.S) square tube. Since M.S is a ductile material, it absorbs the vibration caused due to movement of elements and sustains the weight.

4.2 C- channel:

It is made up of mild steel where the 2 rollers for conveyer are mounted along with the servo motor



Figure:4 Fabricated C- channel

4.3Rollers:

Two Nylon rollers are mounted on the shaft of the servo motor on either side of the C- channel. Rollers are provided with the teeth which helps in gripping of the conveyor sheet while rotating.



Figure:5 Rollers mounted on the shaft

4.4 Nylon sheet for conveyer:

Nylon rubber belts are used as conveyor which move on the nylon gear.



Figure:6 Conveyor mounted on the shaft

4.5 Guide rod block:

It is made up of steel of grade C45, which holds the carbide cutting tool. Since the block and the guide rod are in contact, there will be friction between them, the brass bush is provided between guide block and guide rod to reduce wear and tear of the block.

4.6 Guide rod:

Standardised guide rod of 1200mm length made up of 20mncr5 case hardened material is used which has a good wearing resistance properties.

C	Mn	Si	P	S	Cr
0.17-0.22	1.10-1.40	0.40 max	0.035 max	0.035 max	1.00-1.30

Table 1: Chemical composition of 20mncr5:

4.7 Servo motor:

This is a Mitsubishi drive and AC brushless motor for small routers, plasmas, and benchtop machines.

Specification	Description
Watts	400 W
Supply current	3-phase 230V AC 50/60hz
Current	2.7A
Peak current	8.1A
Max torque	3.8 nm
Speed	3000 rpm
Max. RPM	4500
Shaft diameter	14mm
Shaft length	30mm

Table 2: Specification of servo motor

4.8 Pneumatic circuit:

Three numbers of 5 ports, 3 positions, Double solenoid, Closed centre, Spring return, Pilot operating is used to actuate pneumatic cylinders. The working Pressure of the cylinder is 2 to 10 bar

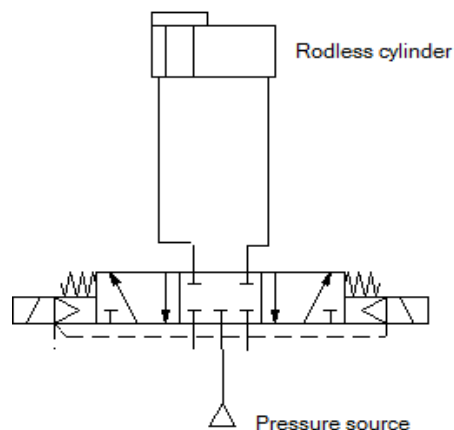


Figure7(a): Pnuematic circuit Design



Figure7(b): Fabricated pneumatic circuit

4.9 Pneumatic cylinder



Figure 8a: rod less Pneumatic cylinder

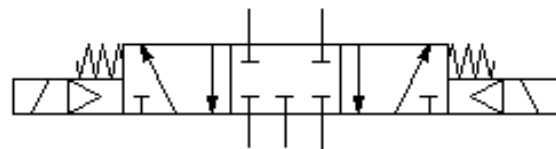


Figure 8b: pneumatic 5/3 valve symbol

- Rodless cylinder of bore Ø25mm is used as shown in the fig. 8a. It has stroke of 100-5700mm and a max. impact force of 2800N.
- Fig. 8b shows the 5/3 valve symbol used to control

5. Working principle:

- Place the mirror to be cut on the conveyer in between the adjusting bush and switch on the mains of the PLC and press start button.
- Each operation can be done at a time by selecting the options in HMI screen so that any errors occurred can be checked or complete operation can be done at a single time.
- When the start button is pressed, the conveyor starts moving along the tool. As soon as the mirror touches the butting pad the conveyer stops.
- The pneumatic cylinder at the clamping plate actuates to clamp the mirror firmly.
- Then the guide rod block holding the tool actuates and moves in forward and reverse stroke on the mirror so that the mirror is scribed.
- The cylinder fixed to the breaking plate actuates the plate and mirror is cut along the scribed mark and clamping plate gets unclamped.

Advantages of glass cutting machine:

- Simple in construction.
- The accidents caused due to the operation in minimal.
- Highly skilled labours are not required i.e., easy in operation.
- The production rate is increased.
- Quantity of Rejections are decreased.

6. Result:

- The time taken to cut a sheet of mirror of dimension 1200*900 into the size of 71*118 is noted down.
- First whole sheet is cut in to the dimension of 118*900 of 10 pieces, the time taken for this process is about 3min.
- Then each piece of size 118*900 is cut into size of 118*71, the time for this process is 2.5min.
- The hourly production observed is around 220 pieces, whereas the hourly production rate for manual cutting operation is 95-100 pieces.

7. Conclusion:

This project work helps to know more about the designing of machine elements, machining process, material selection, pneumatics and automation. And, the purpose of integration of computer in manufacturing sector for automation is achieved. Also, hourly production rate due to automation is twice compared to the manual operation with decrease in the rejection.

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