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# Automatic Pneumatic Based Stamping Machine

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**Abstract**: With the increasing advancements in the automation sector, the need for automation in packaging is also developing dramatically. One of the major processes of packaging is stamping and sealing the final product. Before the industrial revolution, there was little advancement in this field. To exemplify, initially, it was a manual task and the workers used to stamp the product by hand, which took a lot of time and manpower. Also, the use of hydraulics systems is dangerous for instance hydraulic fuel is prone to ignite and thus it makes the whole system dangerous to use. Further, the small and medium scale industries could not afford the expensive automatic stamping machines at that time. To overcome this problem, we came up with the idea of a portable and automatic stamping machine using pneumatic for all kinds of tasks. This standard and optimized stamping machine can be used by all kinds of industries. This paper will bring out the design and implementation of a stamping machine using the described components.

**Keywords**: Stamping Machine, PLC (Programmable Logic Controller), ESP32 – Bluetooth Controller, Pneumatic cylinder, DCV (Direction Control Valve), FCV (Flow Control Valve), Solid State Relay, Ladder Logic Programming

## I. INTRODUCTION

Conventionally the stamping process was manual and it is prone to human errors. While the automatic stamping machine gained so much attention because it is dependable and consistent as stated in a research paper [1]. Whereas the manual task is not always consistent. At the brain of this process is a Mitsubishi PLC which has 15 Inputs and Outputs used for feedback. Also, the danger for workers working in uncertain and unsafe environments can be overcome by this machine. We have used a small power yet high torque AC induction motor to reduce this machine's overall cost. As the overall weight of the conveyer belt and bearing increases the need for a high torque motor arises. The basic construction of our prototype can be seen in the below figures (Figure 01). Automation will vastly increase the productivity and accuracy of the output and it is readily accepted by all the nations over the world, as it is a one-time investment and it reduces the cost by tightening the corners.

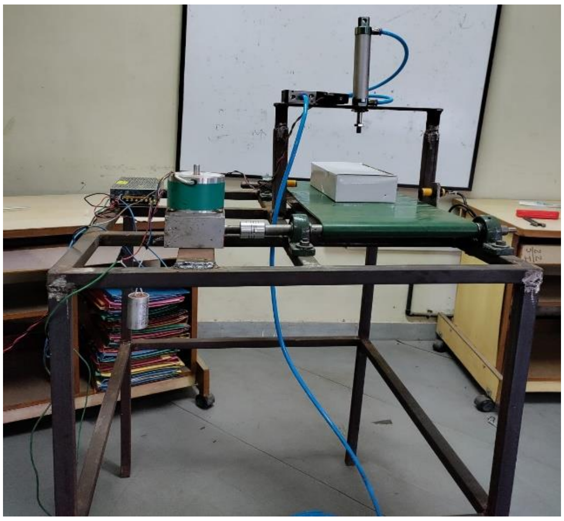

Figure 01: Prototype

## II. WORKING ON THE MODEL

The process initiates with placing the required object onto the conveyer belt. On the edge of this belt is mounted an Infrared Proximity sensor that senses the object. For this purpose, we used a cheap and reliable E18-D80NK proximity sensor that works perfectly with the required power supply and logic level and has a scalable range that can be changed

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with the help of a screw. This sensor is attached with the PLC as input and changes the output as high whenever any object is sensed by it within the determined range. When the object is sensed and PLC receives a high logic it commands the micro-controller; in this case, ESP32 to stop the motor. A Solid-state relay is used here to start and stop the motor as well as change the speed of the motor. The micro-controller then commands the relay to stop the motor. As soon as the motor is stopped the process of stamping starts.

The pneumatic cylinder with a sample stamp on its end is attached here. We opted for a feedback system in which it gives the PLC the command whether or not the stamp has been successfully done or not. For this purpose, we used a reed switch and mounted it on the pneumatic cylinder. The pneumatic cylinder used here is a 100mm stroke cylinder with a magnetic piston. The magnet on one end of the piston will actuate the reed switch which is also attached as an input in the PLC[4]. When PLC reads a high logic of the reed switch it will again command the micro-controller to start the motor, and on receiving the command from PLC the micro-controller will command the relay to start the motor.

All in all, this completes the automatic stamping process. To make this process more robust we mounted two sensors; one before the pneumatic cylinder and the second after the cylinder. For further advancements in this machine, the Bluetooth controller is also able to send the number of products stamped to any of the cloud or web-based platforms for remote data acquisition and visualizing by the worker or the responsible person. The required air for the pneumatic is supplied by a small on-board air compressor and the actuation of the cylinder is made possible by a 3/5 direction control valve the force of the cylinder can be controlled by two small Force Control Valves which are already mounted on both the ends of the pneumatic cylinder.

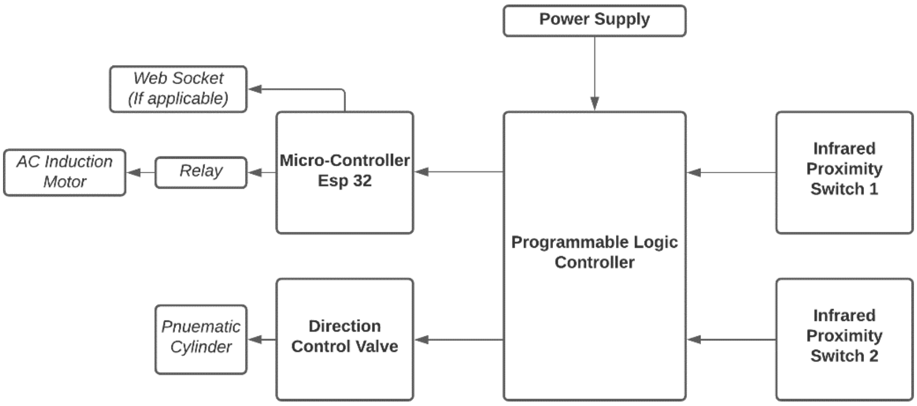


Figure: 02 Working Diagram of the Project mode

For controlling the speed of the AC motor there are many ways which need the motor drivers like variable frequency drivers which can eventually increase the overall cost of the machine. Rather we decided the come up with a more sophisticated idea. To control the speed of the AC motor we need to vary the input logic of the Solid-State Relay. This relay accepts 3-32v DC as input and controls a 240VAC as an output. To change the input of the relay we used a PWM – Pulse Width Modulation which is a varying DC voltage that can be changed using the software. To cope with the frequency of the AC supply we changed the switching frequency of the PWM voltage using the internal timers of the micro-controller. We changed the default 1000HZ PWM signal to a 50HZ PWM signal by changing the bits of the timer [2]. Finally, by commanding the relay with desired variable DC voltage the speed of the AC motor changes.
Although changing the speed of the motor was not necessary for our scenario but we thought it would be productive if we could increase the number of stamps per hour. Also, as Solid-State Relay is just a switch, we were somewhat successfulin switching the speed of the motor.

A secondary system was also developed in which the Infrared sensor was connected with the micro-controller as the logic level is supported by the controller and upon directly reading the sensor the command for stopping/starting the motor can be given to the relay.

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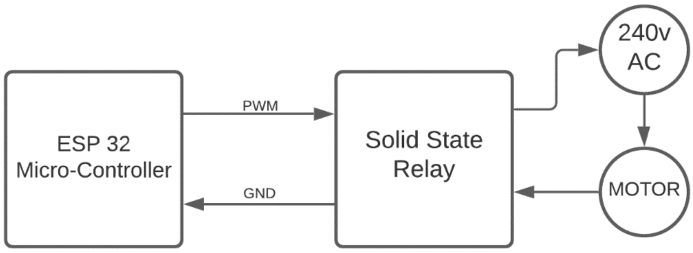


Figure: 03 Pin Diagram of Prototype

## III. SENSOR SELECTION

The selection of the sensor was mainly based on its availability, price and ease of usage. For object detection, we used the E18-D80NK infrared proximity sensor which works on the same principle as IR sensors. It works perfectly on 3.3 and 5v logic levels. To drive the AC motor and control its speed we used a 24-340VAC Solid State Relay. Although the motor does not consume more than 4 amps of current it is always nice to keep some room for extra stall current*. For detecting the position of the pneumatic cylinder, we opted for a 10-Watt 5/240 V AC/DC industrial-grade reed switch. It is also compatible with PLC and has an indentation LED mounted on it.

## IV. MATERIALS AND METHODS

### 1. ESP32 – Micro-controller

It is a 32-bit dual-core micro-controller with Bluetooth and Wi-Fi functionalities. We used a PWM pin of this controller and a digital input pin to read the proximity sensor for our usage. Majorly all the pins in this controller are analog output pins (Figure: 04).

Figure: 04 ESP32 devkitv1(Image credit: sunrobotics.com)

### 2. Programmable Logic Controller

A PLC is a robust industrial computer used in rugged processes like manufacturing tasks, assembly lines, and many more. We used a Mitsubishi PLC with minimum I/O(s) and also it easy to program this PLC using their proprietary software and programmed it using ladder logic [4].

### 3. Solid State Relay

It is an electronic switch that is mainly used to switch AC loads as well as high amp loads. We used the below-shown SSR with Zero-Cross detection* (Figure: 05)

Figure 05: 25A Solid State Relay (Image credit: electronicscomp.com)

 

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**4. Direction Control Valve**

This type of valve is controlled electrically and allows a flow of fluid/gas in two different directions from one or many sources. It consists of a magnetically attracted spool (Figure: 06).

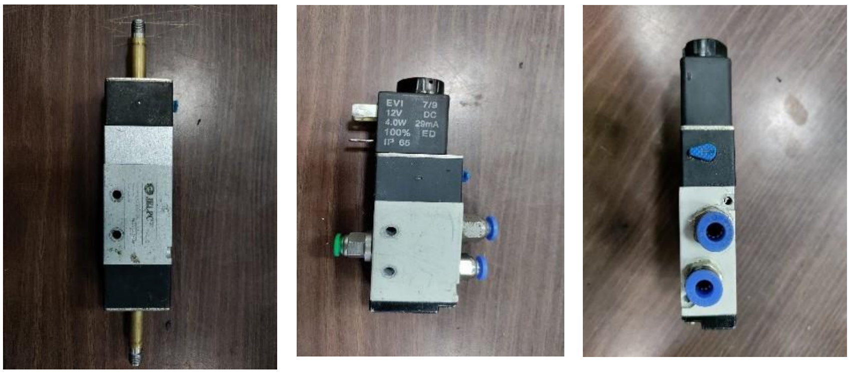

Figure:06 Direction Control valve with Solenoid

*1bar = 14.5038 Pound Per Square Inch

*Zero-Cross Detection allows the relay to turn ON when the AC supply reaches 0V to suppress the noise generated by the sudden inrush current used by the load. (In this case AC motor)

- **METHODS**

For simulation purposes, we used PLC Simulator to test our PLC ladder logic. As this was for testing purposes, we used an online PLC Simulator which includes all the basic ladder commands. There are in total 8 rungs and the process starts with a start/stop switch. As the switch is set it will next command and star the motor; here it commands the ESP32 micro-controller. It also checks whether the command is reinitiated or not. As the proximity is set and command is received by ESP32 it stops the motor and the Direction Control Valve (Solenoid Valve) is actuated eventually actuating the Pneumatic Stamp. After a delay of 10 Seconds (this value was set based on trial and error) the command is again sent to ESP32 to start the motor and here the variable count is the reed switch which counts the number of Pneumatic stokes performed. i.e., the number of products stamped (Figure 07).

Now with the micro-controller, we used the input pins to read the input from PLC and made the use of Logic Level Converter which converts the 10V PLC logic to usable 3.3V ESP32 logic level. With an abstract implementation of Wi-Fi and webserver, we sent the number of products stamped to the webpage, although the development of the application was still in progress (Figure 08).

The overall supply to the machine was provided with a 24V-5A SMPS (Switch Mode Power Supply) whose input is an AC supply.

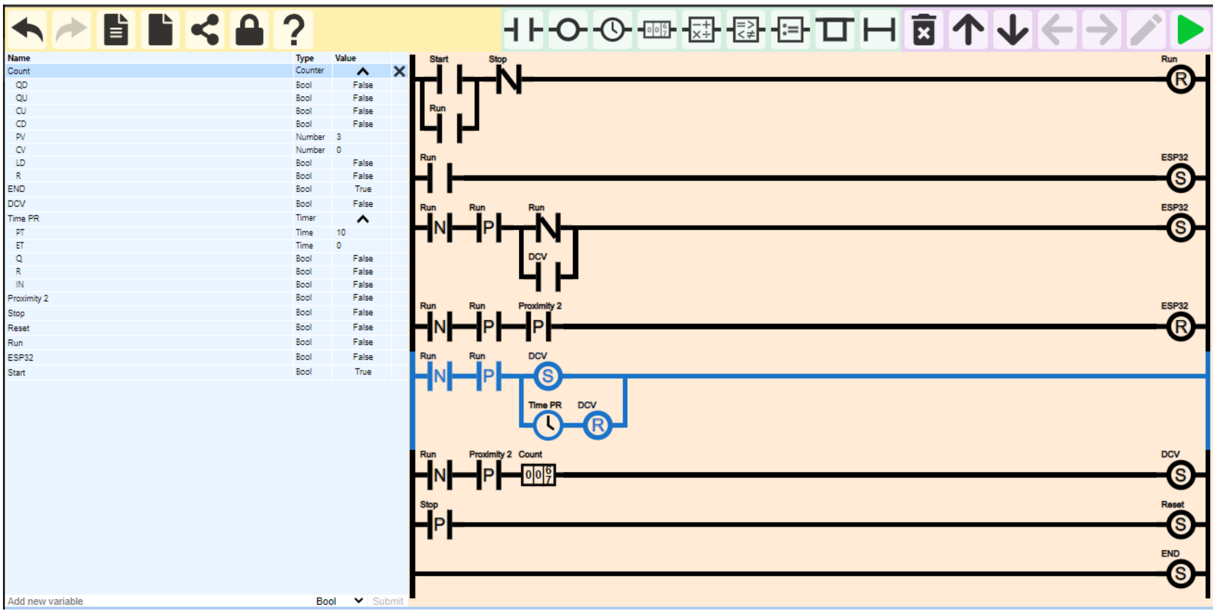


Figure 07: Sample Ladder logic using timer and counter

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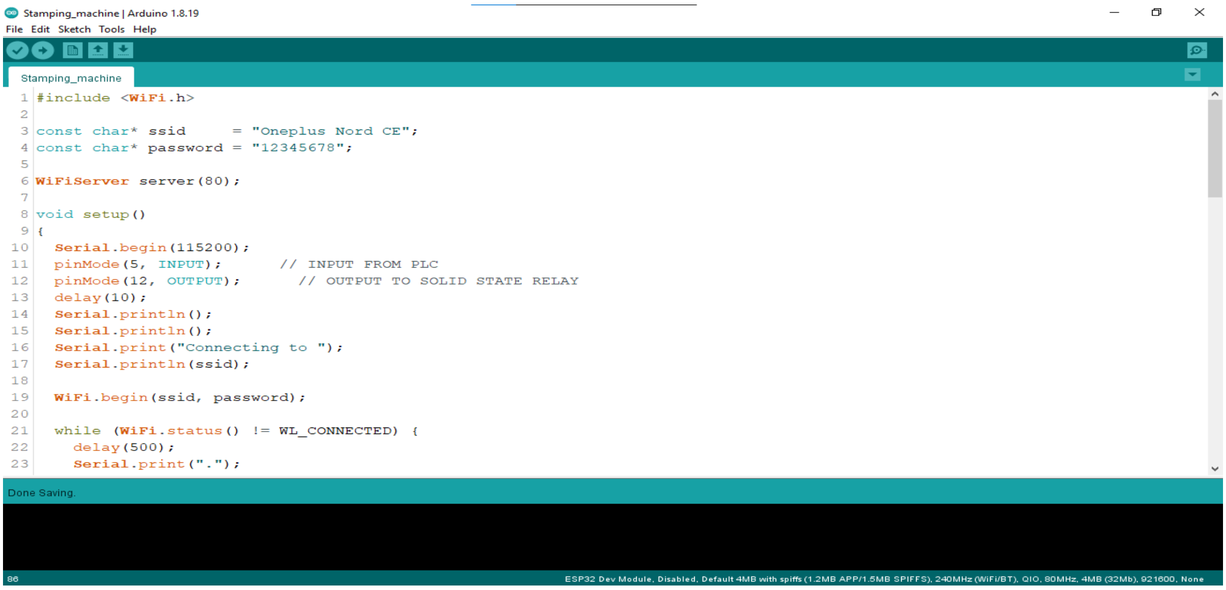


Figure 08: Code for Webserver and Driving the motor

## V. LIMITATIONS

There were many challenges faced by us during the testing and prototyping stage of this product. After thoroughly solving them, we came to know about the limitations of this machine. Firstly, although it is applicable on all kinds of products if we specifically consider the heavy materials like a batch of beverages the overall weight of a single batch could buckle* the belt resulting in stalling of motor and delay in stamping. To overcome this a high torque motor must be used along with a plastic interlocked belt or metal belt which can withstand the weight of the sample products.
Secondly, we observed that if the machine is to be built loosely, the cost of maintenance will increase dramatically.

*Buckling is the sudden change in the shape of the component under load

## VI. CONCLUSION

The prototype we have made is very cost-effective and economical compared to the solutions available in the market. The use of Pneumatic makes this a hazard-free solution. As stated above, the use of hydraulic or any other actuating methods has the bottleneck of usability in certain tasks and processes. This system is very accurate and efficient in performing such tasks automatically. But all in all, no task can be completely automated escaping the intervening of humans.

## VII. FUTURE SCOPE

As it is an early-stage idea and lots of development is made in these Industrial revolutions, we intended to perform the task with the best accuracy and efficiency. But as far as the future scope of this product is concerned, the concepts of Industrial 4.0 can easily be integrated into this device making it more versatile and remote supervisory of the number of stamps made can also be merged with this idea. Summing up there is always some room for automation advancements to be made in future. Furthermore, if one wants to control the input pressure of the pneumatic cylinder so that the product does not damage then a Proportional Pressure Regulator/ Electronic Pressure Regulator can be used. The PPR/EPR works by supplying analog voltage to the sensor and the more advanced flapper nozzle arrangement controls the output pressure to the cylinder.

## VIII. ACKNOWLEDGMENT

We are thankful for our project guide **Prof. M.M. Sharma** for allowing us to pursue and work on this Pneumatic and PLC based project and encouraging us in deeply learning the concepts of a control system and programming of both AVR based controllers and ladder logic for PLC with his proper guidance and we also learned the working of Pneumatic cylinder and its accessories. We also thank our **Head of Department (I&C) Dr M.K. Shah** for providing

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all necessary facilities and guidance.

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