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PLC Based Automatic Stamping Machine for Labeling the Boxes

Khin Thet Pie[1], May Su Hlaing[2] , Tin Tin Hla[3]
khinthetpy@gmail.com[1], maysuhlaingytu@gmail.com[2], tintinhla99@gmail.com[3]
[1,2,3] Department of Electronic Engineering , Mandalay Technological University, Myanmar

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Abstract

Stamping machine plays a vital role for automation industy. There have consisted of two main parts. The results of this system has been demonstrated with supervisory control and data acquisition (SCADA) systems software and hardware. MS 32MT PLC has been applied to control and sensors and limit switches has been used to get good accuracy and start and stop condition of this system. The combination of PID and PLC have been and the desired value in conveyor system aims to maintain and the the system is stable. This system has been used for labelling the boxes in automation industry that have been carried on conveyor and chosen the box's size by the use of laser distance sensors at robot arm system. The correct box's size has been detected with proximity sensor and stamped the boxes. The aim of automatic stamping machine is the prototye machine to apply in automation industry.

A. Introduction

The stamping machine system consists of hardware and software. Mistsubishi Fx series PLC and ladder diagram by GX work 2 software have been used the entire control system. Conveyor system, robot arm system and stamping system have been designed to ensure and to be good accuracy for mini industry. PID (Proportional-Integral-Derivative) control is one of the most common control algorithms used in PLC programming. Conveyor systems are commonly used in many industries, including the automotive, agricultural, computer, electronic, food processing, aerospace, pharmaceutical, chemical, bottling and canning, print finishing and packaging[3].This system has used a PLC and PID loop for controlling the speed of a conveyor. The PID control algorithm is implemented in Mitsubishi FX series PLC programming through a combination of ladder logic with GX work 2 software. The robot arm is widely used in automation industries to transfer the products from one location to other. A basic PLC motion control system consists of a controller, a motion module, a motor driver, one or more motors with encoders, and the parts of machinery. Stamping machine has been stamped the correct boxes' size after choosing the robot arm incorrect boxes' size. SCADA system provides extensive capabilities for real-time monitoring, control, and data acquisition in industrial environments. The structure of stamping machine has been constructed by applying solid work software and then maked it.

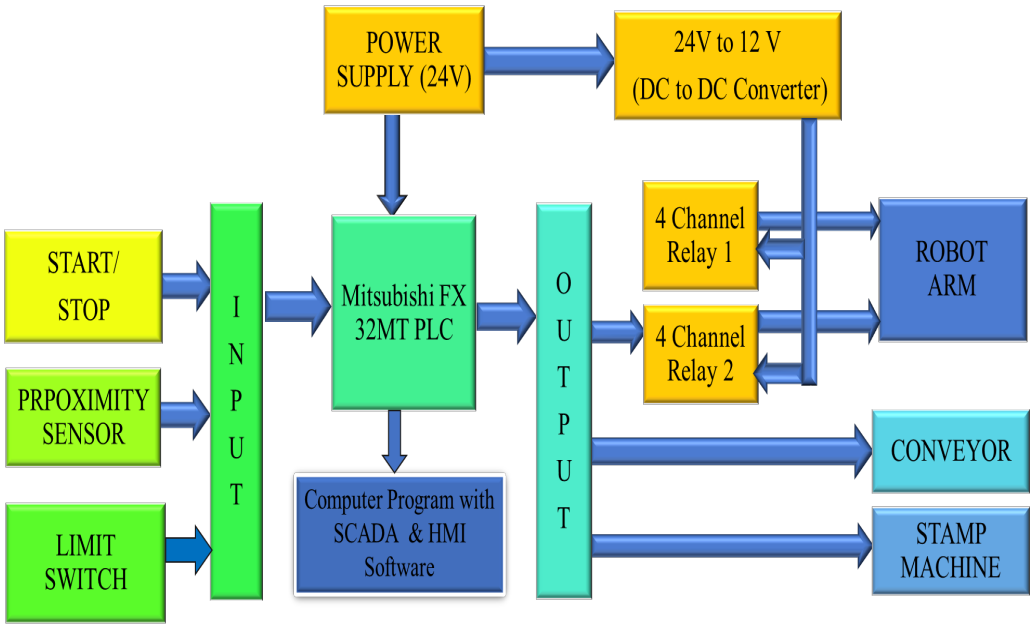

Figure 1. Block Diagram of Stamping Machine

The concepts of stamping machine with block diagram has been expressed in figure 1. In power system, 24 V power supply has been applied to Mitsubishi Fx series PLC and four channel relays, 24 V to 12V dc to dc converter has been used to run the robotic arm system The automatic stamping system has been designed to complete that one bruch DC motor has been used for conveyor, five dc motor have been used for robot arm and one stepper motor

has been used for stamping machine. Four sensors have been used for picking and placing the incorrect boxes' size and stamping the correct boxes' size.

Purva Rakhade has described, "PLC BASED PNEUMATIC PICK AND PLACE SYSTEM"[7]. The proposed system include hydraulic system, pneumatic system, servo motors. There are some basic mechanisms like piston-cylinder motion, mechanical arm movement, etc. The proposed project is based on pneumatic system. The entire design is operated using Programmable Logic controllers (PLC).

Mewada Yash, Waghela Harshwardhan, Pandya Hetanshi, Prof. M.M. Sharma have presented "Automatic Pneumatic Based Stamping Machine" [13]. The proposed system applied pneumatic cylinder with a sample stamp and feedback system in which it gives the PLC the command whether or not the stamp has been successfully done or not. For this purpose, a reed switch has been 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 a high logic of the reed switch has been read, PLC command the micro-controller to start the motor, and on receiving the command from PLC the micro-controller command the relay to start the motor.

B. Research Method

The automatic stamping system has been considered the choice of components, constructed the design of stamping system and shown the hardware result and software results with the SCADA.

(a) Choosing the Components of Stamping Machine

The components have been choosen to construct the automatic stamping machine and have been shown in the following Table 1.

Table 1. Components of Stamping Machine

No	Components
1	K2 driver CH 340/341
2	RS 485
3	1GA 25-370/60RPM Brush DC Motors
4	1GA 25-370/130RPM DC Motor
5	360/600P/R. Stepper Motor(17HS4401)
6	Incremental Rotary Encoder (HDE38S6-360-N-12-24DC5V-24V)
7	4 Channel Relay
8	L298N
9	Limit Switch
10	Gripper

(b) Structure of Automatic Stamping Machine

The structure of automatic stamping machine has been firstly considered as a figure 2 before making hardware installation with drawing the solid work software. Then, automatic stamping machine has been again considered to construct according to figure 3 and figure 4 to be safe and to be good accuracy before making hardware installation. The final design of top and trimetric view of automatic stamping machine has been shown in figure 3 and figure 4.The

length, height, size of this system has been set and the size of boxes has been defined and where to move the boxes and stamp them.

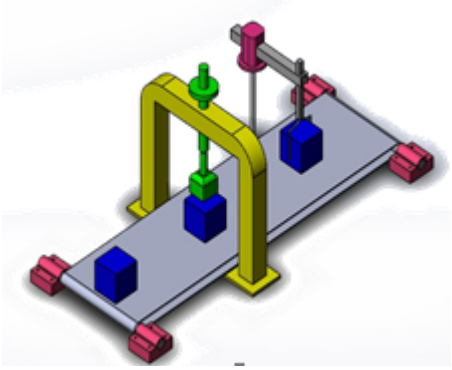

Figure 2. First Design of Automatic Stamping Machine

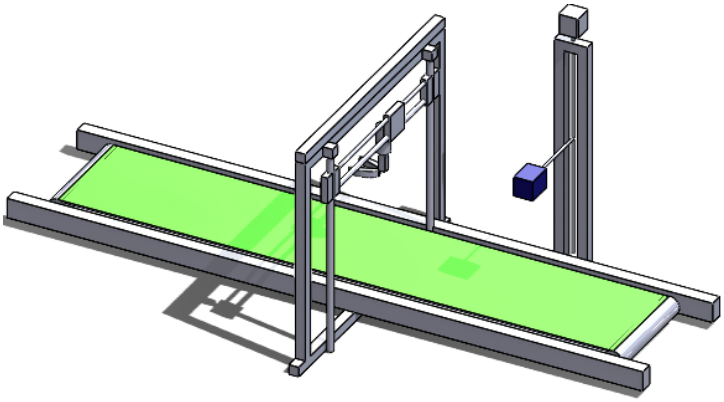

Figure 3. Final Design for Trimetric View of Automatic Stamping Machine

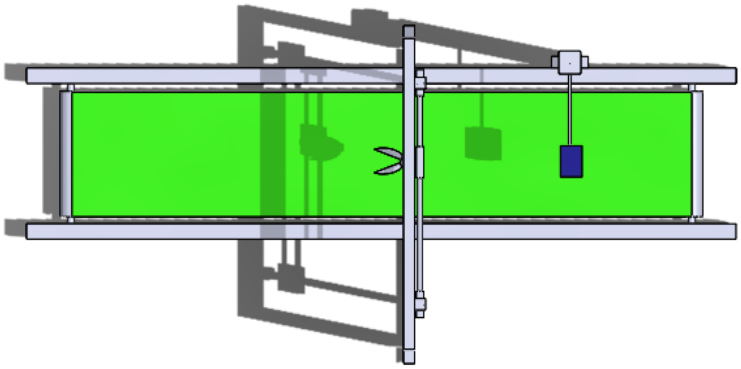

Figure 4. Final Design for Top View of Automatic Stamping Machine

(c) Modbus function

Modbus or MODBUS is a client/server data communications protocol in the application layer.It was originally designed for use with programmable logic controllers (PLCs), but has become a defacto standard communication protocol for communication between industrial electronic devices in a wide range of

buses and networks. The Modbus protocol uses serial communication lines, Ethernet, or the Internet protocol suite as a transport layer. Modbus supports communication to and from multiple devices connected to the same cable. Modbus is often used to connect a plant/system supervisory computer with a remote terminal unit (RTU) in supervisory control and data acquisition (SCADA) systems.

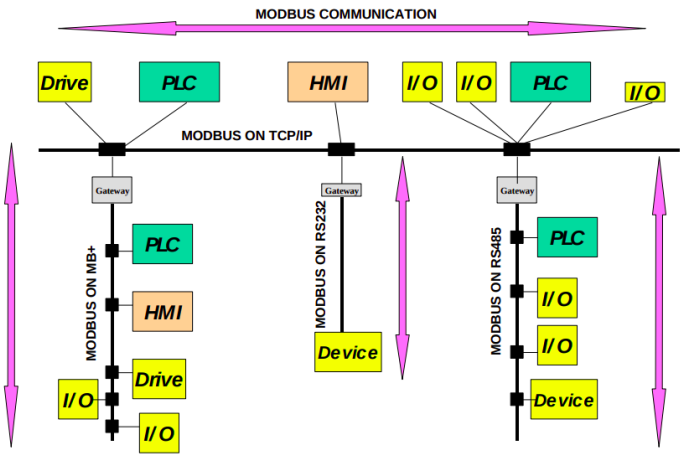

Figure 5. Modbus data model [1]

Modbus defines its data model based on a series of tables of four primary types [15].

Table 2 Modbus data model

Primary Tables	Access	Size	Features
Discrete input	R	1 bit(0-1)	Read on/off value
Coil (discrete output)	R/W	1bit(0-1)	Read /Write on/off value
Input register	R	16 bits words (0-65,535)	Read measurements and statues
Holding register	R/W	16 bits words (0-65,535)	Read / Write configuration values

(d) SCADA

SCADA displays live process data collected from field devices like sensors and PLCs. Line graphs showing parameter changes over time.

Graphical Indicators shows the animations of Processes for the stamps turning on/off, conveyor belts moving, arm picking/placing. Animated Process Representation, SCADA systems often show schematic diagrams of the plant with real-time status updates. Color-Coded Equipment Status: Green (running), Red (alarm), Yellow (standby), etc. Analysis and Historical Data,SCADA stores data over time and displays trends to analyze performance. Real-Time and Historical Trends and Comparative Analysis Control Commands Feedback and

the perators can issue remote commands via SCADA, and the interface provides feedback: such as Start/Stop Control with Status and Setpoint Adjustments. Finally Geographic Information System (GIS) Integration SCADA systems present a combination of real-time data, alarms, historical analysis, and animated process flows to help operators efficiently manage and control industrial systems.

(e) System flow chart of Stamping Machine

The combination of conveyor system, robotic arm system and stamping process have been clearly expressed with the flow chart of stamping machine show the figure 6.

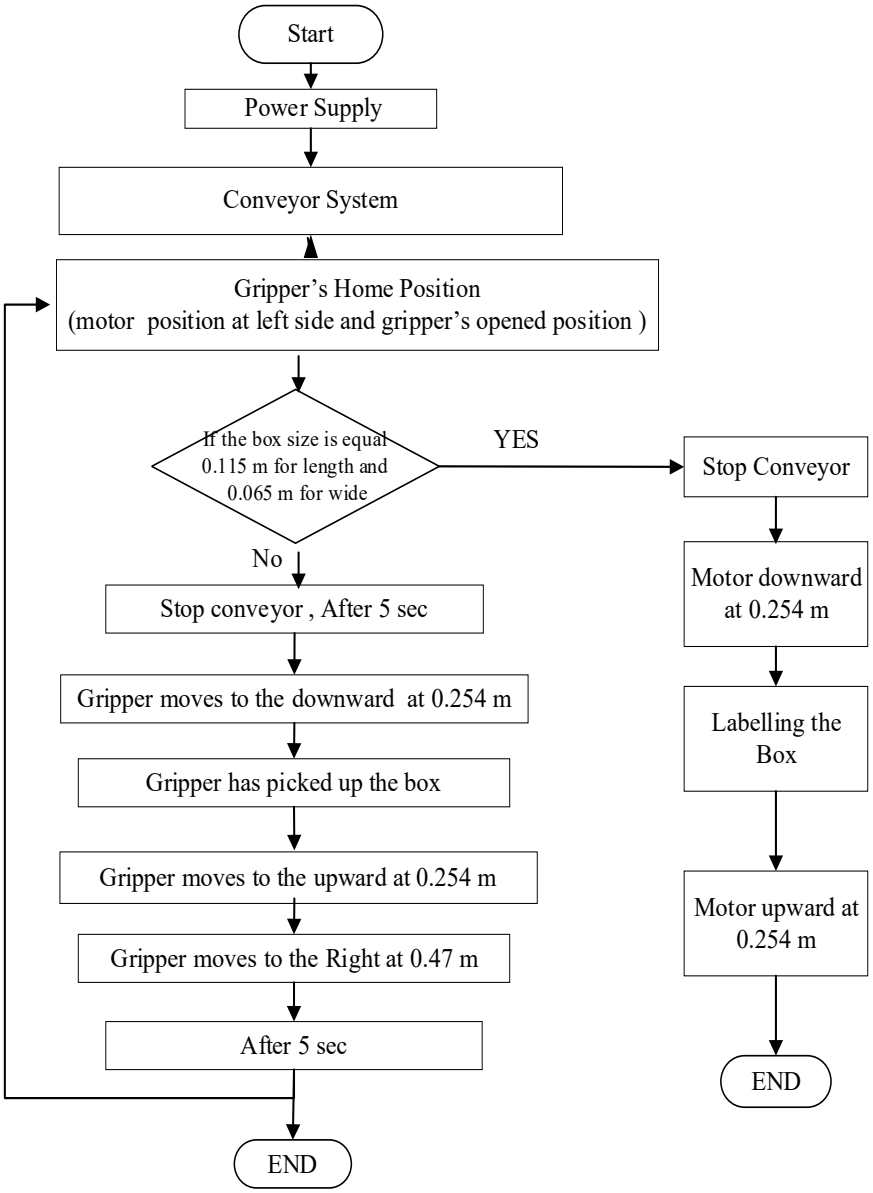

Figure 6. Flow chart of Stamping Machine

The flow chart of Stamping Machine has been expressed in Figure 6. 24 V dc power supply has been applied to PLC and 12V dc power supply apply to robot arm and stamping machine. In robotic arm system, There are big size, small size and correct sensing with sensor 1, sensor 2 and sensor 3. After conveyor stop the running at this time, the arm at home position moved downward to pick the big box or small box and then moved to the upward direction with big box or small box and direction changed to the right side for placing the big box or small box and gone back at home position. Finally, if the box size contacted with sensor 1 and sensor 2 and timer also match for box running condition, it is correct size. The robot arm will not activated and stamping system has proceed to stamp the box for labelling. The conveyor travelled with boxes and sensors sense the correct box's size . Then it is correct conveyor stop and stamping machine stamped the box for labelling and conveyor has cotinued to move on.

(f) PID Control Algorithm

The PID controller block diagrarm with feedback closed loop control system block diagram has been described in figure 7.

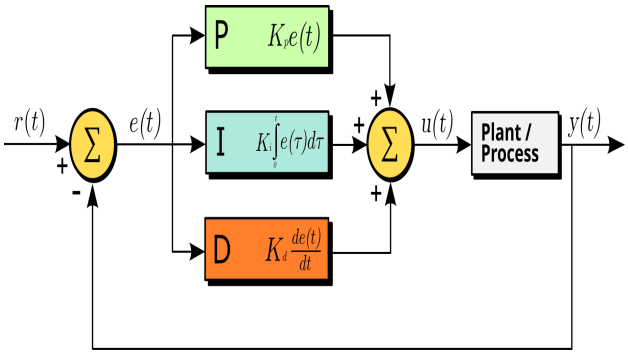

Figure 7. A block diagram of a PID controller in a feedback loop. $r(t)$ is the desired process variable (PV) or setpoint (SP), and $y(t)$ is the measured PV[16].

PID controller, which continuously calculates an error value as the difference between a desired setpoint and a measured process variable :

SP= r(t) (1)

PV= y(t) , e(t) = r(t) – y(t) (2)

The proportional term is given by

$P_{out} = K_p\, e(t)$ (3)

The integral term is given by

$I_{out} = K_i$ (4)

$$I_{out} = K_i \int_0^t e(\tau)d\tau \quad (5)$$

The derivation term is given by

$$D_{out} = K_d \frac{de(t)}{dt} \quad (6)$$

Table 3. Effects of Increasing A Parameter Independently

Prarmeter	Rise Time	Overshoot	Settling time	Steady-state error	Stability
Kp	Decrease	Increase	Small change	Decrease	Degrade
KI	Decrease	Increase	Increase	Eliminate	Degrade
KD	Minor Change	Minor Change	Descrease	No effect in theory	Improve if Kd small

(g) Input and Output Description of Stamping Machine applied PLC based PID

The input and output description of this sytem is expressed in table 4 and 5 for Mitsubishi Fx PLC.

Table 4. Input description of Stamping Machine

No	Input	Descriptions
1	X0	Encoder
2	X1	Encoder
3	X2	Sensor 1
4	X3	Sensor 2
5	X4	Sensor 3
6	X5	Stem Sensor
7	X6	Grip Open
8	X7	Down
9	X10	Up
10	X11	Right
11	X12	Left

Table 5. Output description of Stamping Machine

No	Output	Descriptions
1	Y0	Stem
2	Y1	Conveyor Motor
3	Y2	Stem
4	Y3	Motor Down
5	Y4	Motor up
6	Y5	Motor Left
7	Y6	Motor Right
8	Y7	Gripper Close
9	Y10	Gripper Open

C. Result and Discussion

The results of automatic stamping machine system for hardware and software has been details described in this section. There are consist of three main parts that there are convyeor system, robot arm system and stamping machine. The system has been expressed the initial condition, choosing the big and small boxes' size on conveyor to remove it with robot arm system and stamp the correct boxes size.

The figure 9, figure 10, figure 11, figure 12, figure 14, figure 16 and figure 18 shows a SCADA animation. Scaled Input (Yellow) shows the input setpoint values. Current Reference (Blue) is the real-time measured value from sensors. Output (Orange) displays the PID control output that drives the conveyor.

Horizontal Axis (X-Axis) represents time in seconds and Vertical axis (Y-Axis) represents control signal values in percentage (%). The values range from 0 to 100, showing the system's scaled output, current reference, and final output. Run (Green Button) starts the conveyor system and activates the PID control. Setpoint and display values has been inserted to describe the results. Green circular objects on both ends might represent rollers . Stop (Red Button) stops the system. Arrow Buttons used for control of the arm (left, right, up, down) and stamping movement (up, down). The green arrow shows the animation of robot arm system and stamp system.

The initial condition condition of stamping machine with SCADA and hardware result has been described in figure 8 and figure 9.

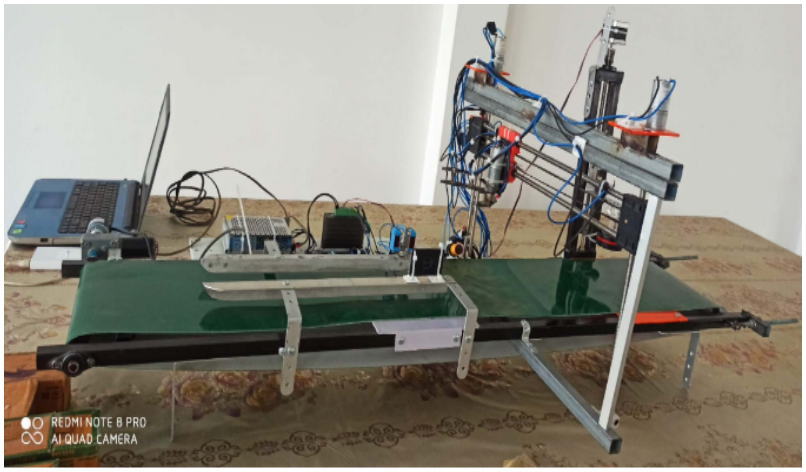

Figure 8. Initial Condition of Stamping Machine

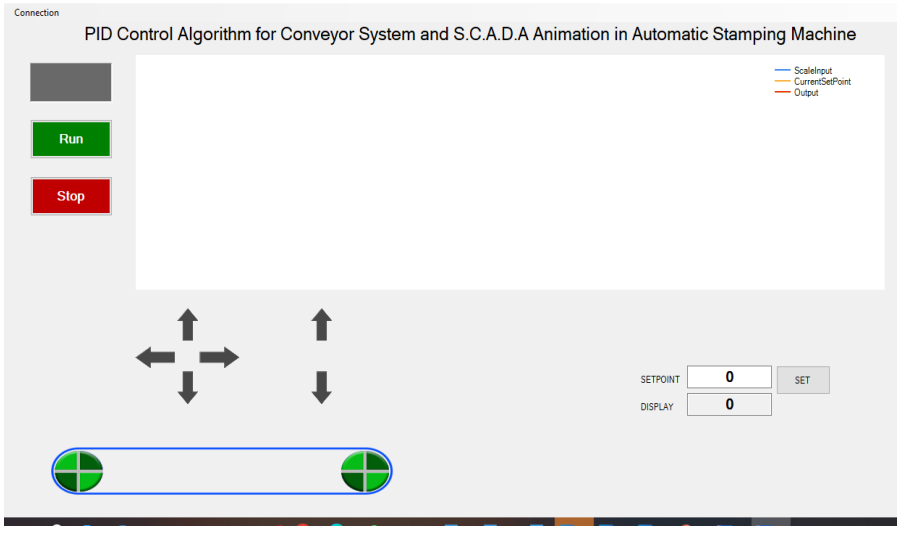

Figure 9. SCADA Result for Initial Condition of Stamping Machine

The Conveyor speed has been set with setpoint(desired speed) and output (actual speed) has been got according to desired speed. PID control adjust the desired set point, current and measured valued has been clearly shown as seen

in figure 10, figure 11 and figure 12. Setpoint box is set up at 80 and other value has been set but not exceed 100.

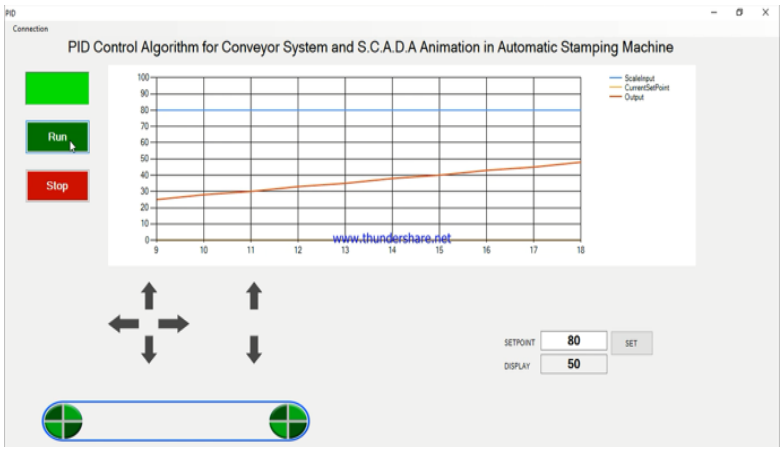

Figure 10. PID Tuning Step Result of Conveyor when the system is run at 80

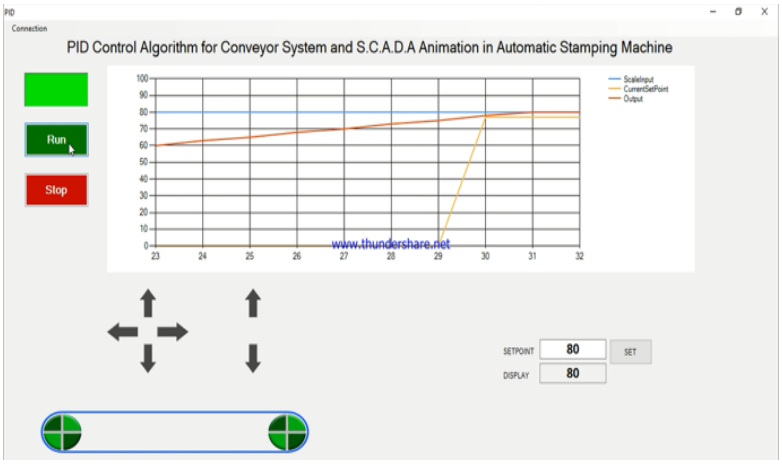

Figure 11. PID Tuning Step Result of Conveyor when the system is run at 80

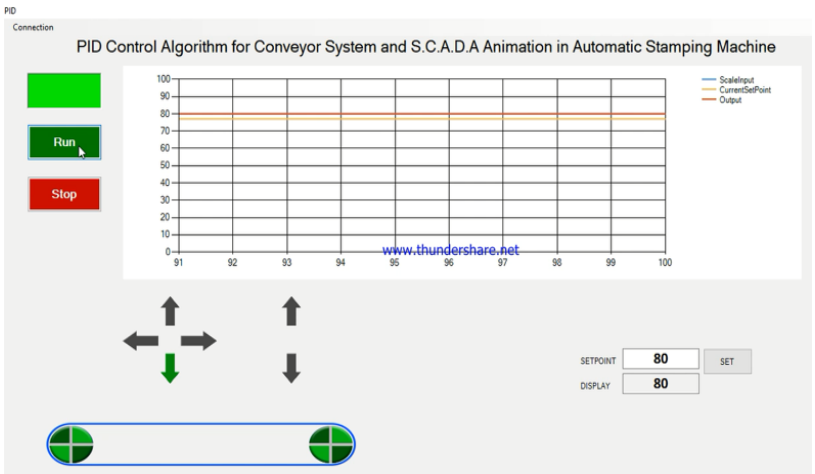

Figure 12. PID Tuning Step Result of Conveyor when the system is run at 80

The Conveyor speed has been set with setpoint(desired speed) and output (actual speed) has been got according to desired speed. The results of conveyor speed with PID control algorithm and hardware results for the box's size is big has been shown in figure 13 and figure 14.

Figure 13. Pick and Place the Box's If The Box's Size is Big

Scaled input (Yellow) and current reference (Blue) and output (Orange) displays the PID control output that drives the conveyor. When setpoint is set up 50, the display shows 50 as seen in figure 14 . If the box's size is contact with sensor 1 and senor 2 and sensor 3 since box on conveyor running time, the box's size is big. Therefore, the conveyor has been stopped and the robot arm has activated to remove this box. Robot arm is at home position (left side) and then moved downward to carried it and up to the right side and released it . Finally the robot arm system has gone back at home position and conveyor continues run. Each arrow concerned with robot arm system showed the relative animation of the robot arm system when it is activated it shows with green color. The arrow bright green colour in figure (14) means that big box has been moved to the right and release it. In this section stamping process has not activated.

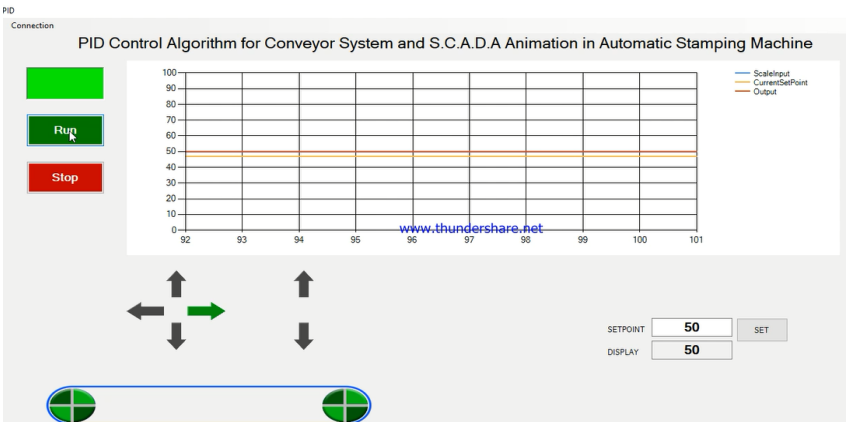

Figure 14. SCADA Result of Stamping Machine if the Box's Size is Big

The Conveyor speed has been set with setpoint(desired speed) and output (actual speed) has been got according to desired speed. The results of conveyor speed with PID control algorithm and hardware results for the box's size is small has been shown in figure 15 and figure 16. Sensors have been detected the box. If the box's size is between sensor 1 and senor 2 and mismatched boxes with timer on conveyor running condtion, the box's is small. Therefore robot arm has activated to remove this box and conveyor has been stopped. Robot arm at home position (left side) moves downward to carried it and then up to the right side released it. It also reaches at home position. Each arrow concerned with robot arm system showed the relative animation of the robot arm system when it is activated it shows with green color. The arrow bright green colour in figure 16 is that small box has been moved to the right and release it . In this section stamping process has not activated.

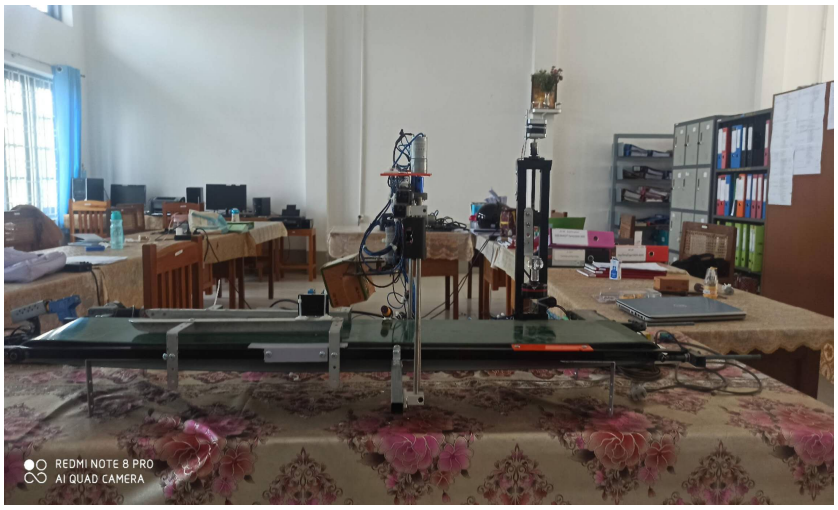

Figure 15. Pick And Place the Box's if the Box's Size is Small

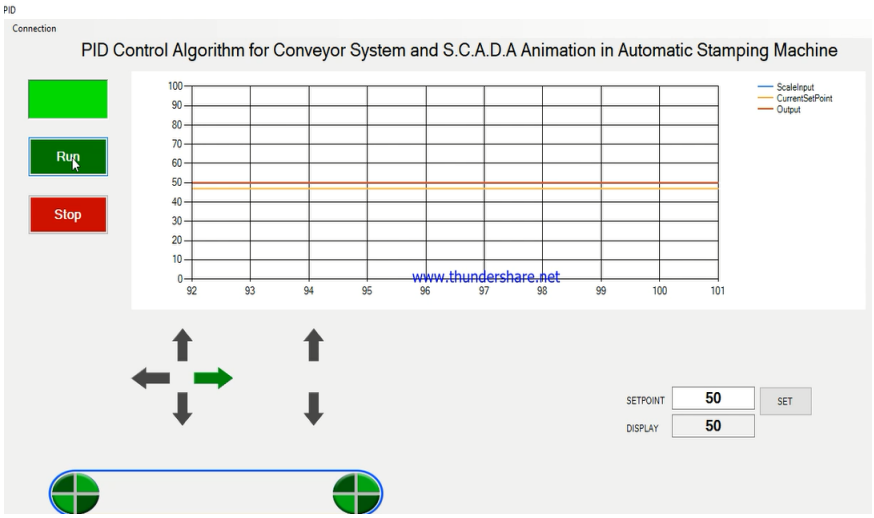

Figure 16. SCADA Result of Stamping Machine if the box's size is small

The conveyor speed has been set with setpoint(desired speed) and output (actual speed) has been got according to desired speed. The results of conveyor speed with PID control algorithm and hardware results for the box's size is correct has been shown in figure 17 and figure 18.

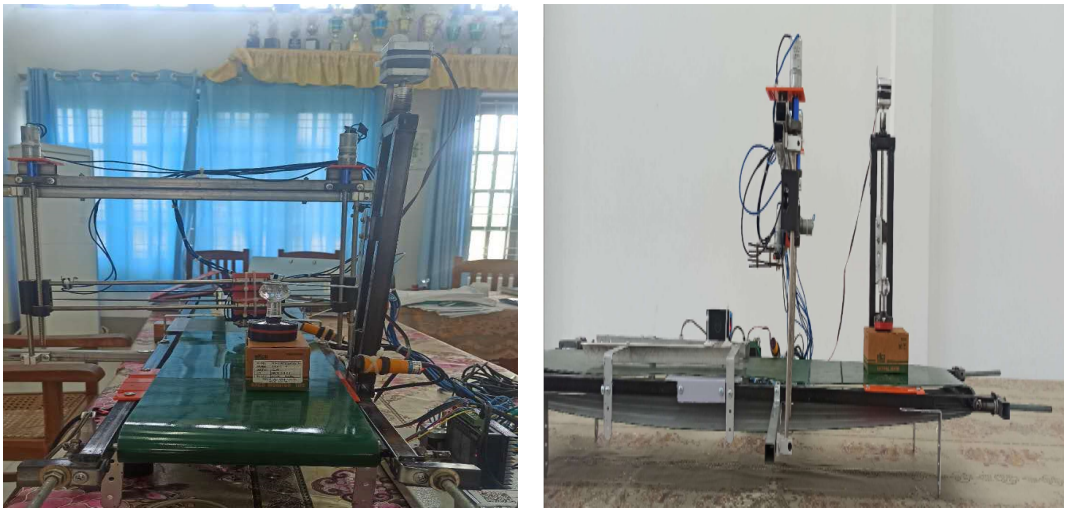

Figure 17. Result of Stamping Machine if the box's size is correct

Green Downward arrow indicates stamp movement of stamping machine and then green upward arrow indicates the stamp moves to normal position by detecting proximity sensor. The blue conveyor belt moves products from one end to another.

If the box's size is contact both sensor 1 and senor 2 and the timer is correct, the box's size is correct. Therefore robot arm has not activated to remove this box. Robot arm is at home position (right side). In this section stamping process has activated to stamp the box by using sensor 4 which is detected to label the box and conveyor has also continued to carry on it.

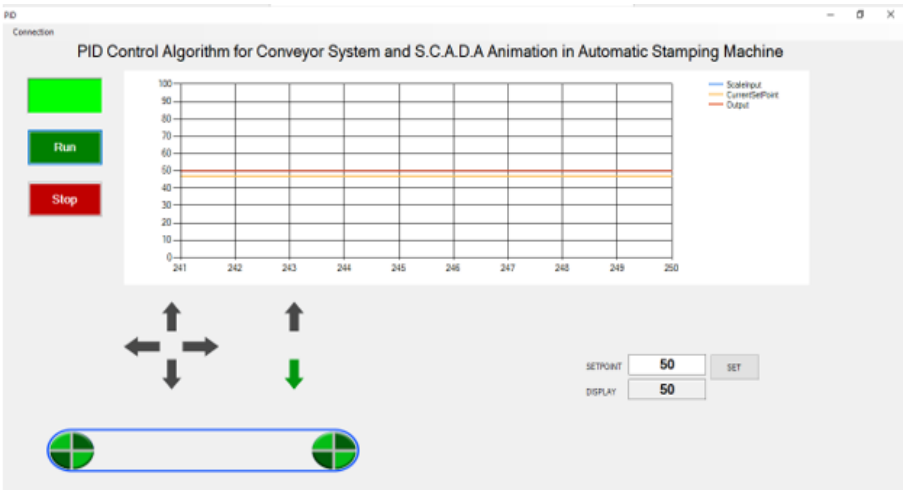

Figure 18. SCADA Result of Stamping Machine if the box's size is correct

D. Conclusion

There are many benefits for time saving and cost effective by making automatic system. Structure of automatic stamping machine has been considered with solidword software before installation of hardware system. Conveyor system has been taken part to carry the boxes through the conveyor and it have been reached pick and place system and finally stamp the boxes. PID control algorithms used in PLC programming to control the speed and analyse of conveyor. PID-controlled conveyor system where the process values (input, reference, and output) are monitored in real-time via SCADA. The goal is to automate the stamping process while ensuring smooth operation with the PID algorithm regulating conveyor speed and positioning. The animation of stamping machine process has been decribed with SCADA. 12V dc motors in robot arm system have been applied to control the up, down, left and right movement. Stamping machine has been stamped the correct boxes' size after removing the robot arm incorrect boxes' size. SCADA system monitored the PID control results and hardware result of automatic stamping process. A combination of PLC control with SCADA integration allows real-time monitoring, data logging, and centralized control. Hardware and software results of automatic stamping machine sytem has been compared to show the real and software demonstration. This system improves quality control and process efficiency and have flexible programming capabilities and are reasonably priced.

E. Acknowledgment

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