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Automatic Feed Sack Stamping Machine using Electro-Pneumatic

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Abstract— *In the current industrial era, competition between companies is becoming increasingly stringent along with the increasing demand for goods in any business sector. Therefore the speed of production is needed for a company to be able to compete. Industrial automation is one way to support this achievement. Industrial automation is considered capable of making a process of production stages run effectively and efficiently. One of the feed production processes is the stamping of feed product packaging at this stage of the process generally still using the manual method, so an Automatic Stamping Machine is needed to increase the value of efficiency in the stamping process. In addition, companies need to have a strategy in the feed production process that must be carried out effectively and efficiently in order to achieve a production process that provides optimal benefits. Therefore, the authors designed an automatic sack stamp machine called "Auto Stamp". In this design, various automation technologies such as PLC, SCADA, and HMI are used. The Auto Stamp machine itself can increase the production of sack stamping which was originally 7800 sacks per day using the manual method to 9000 sacks per day.*

Keywords— ***Automation, Pneumatic, PLC, SCADA, HMI, Stamping Machine, Efficiency***

1. INTRODUCTION

In the current industrial era, competition between companies is becoming increasingly stringent along with the increasing demand for goods in any business sector. Therefore the speed of production is needed for a company to be able to compete. Industrial automation involving sophisticated equipment such as PLC, HMI, as well as electric and pneumatic actuators is a solution to this problem. [1] [2]

The author reviews a specific problem in the form of the process of stamping feed sack type labels which is still done manually in many animal feed production industries. Of course, in this way, the speed at which sacks are tacked cannot keep up with the increasing feed production capacity.

In general, many feed sack designs have two stamp tags on the right and left sides of the sack. This sealing process is still done manually by humans who are considered to be less than optimal in terms of speed. Therefore, the authors are interested in developing ideas to design an automation system to solve this problem. The author developed a design for an automatic sack stamping device with the name "Auto Stamp". The design of this machine is expected to help the production process to provide quantities sacks with a certain type of feed in a short time. In addition, this machine can be a solution if there is a sudden demand for sacks due to changes in the feed production plan. [3]

Fig 1. Stamp tags location on feed sack.

Seen from its name, the design of this machine involves electrical and pneumatic systems. This machine allows the process of sealing sacks in large quantities in one machine work cycle. In general, the way the machine works is to accommodate a pile of sacks totaling 500 sheets and then fold the side of the sack to allow the location of the stamping to be seen so that stamps can be made on both sides of the sack. The folding and attaching mechanism involves a pneumatic system controlled by a PLC (Programmable Logic Controller) which has been programmed according to how the machine works. After sealing, the sacks are then pulled out using

wheels in the form of a motor to go to the packaging or bagging process. Because it has the speed and accuracy of the mechanical work process, the design of an Automatic Feed Sack Stamping Machine using an Electro-Pneumatic system is used as a solution to obtain a more efficient feed production process. [4]

This design is designed so that operators can operate this tool easily where the PLC used is the Siemens PLC S7-1200 type and uses an interface in the form of an HMI (Human Machine Interface) with the Siemens Simatic HMI TP700 type.

2. MATERIALS AND METHODS

2.1 Electro-Pneumatic System

The pneumatic system is a principle mechanism that utilizes compressed air as a source of work. Often, a series of pneumatic systems is designed to consist of several pneumatic components and is integrated with automation control using a PLC so that it is often called an electro-pneumatic system. [5] [6]

2.1 PLC

PLC is the brain of an automation system which functions to carry out logical functions to monitor and control a plant or machine. In the Auto stamp design project, a PLC is used as the controller element with the addition of one input output module. The PLC in this project has 14 Digital Inputs and 10 Digital Outputs. In this design, the additional I/O module is used to provide additional 16 DI and 16 DO I/O slots for the needs of all Auto stamp components. [7]

2.2 Human Machine Interface

Human Machine Interface or HMI is an interface device that functions to bridge the control and monitoring process between the machine and the operator. HMI is often found in the form of a touch screen that has a menu of control buttons and visualization of images from a plant or machine. The HMI is communicated with the PLC via an ethernet cable and programmed simultaneously with the PLC with the TIA Portal V17 software. [7]

As for the design of the Auto Stamp, several sensor, mechanical, and actuator components are used, including:

1. Through Beam Sensors
2. Infrared Proximity Sensors
3. Limit Switches
4. DC motors
5. 3 Phase Motors
6. Ball screw
7. Pneumatic Cylinder
8. Solenoid Valves
9. Siemens Servos and Drivers
10. Scissor Lift
11. Liquid Level Sensor

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3. DESIGN OF AUTO STAMP MACHINE

3.1 Structural Design and System Mechanization

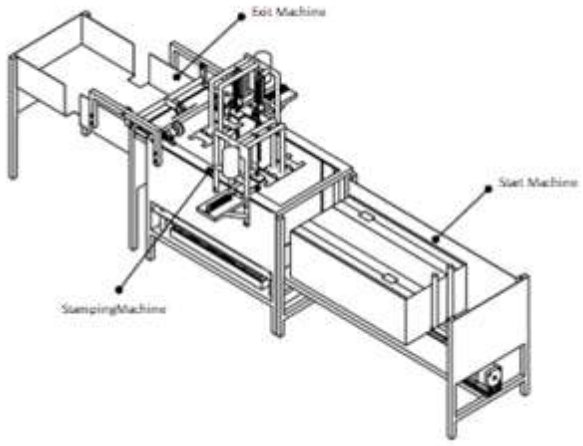

Fig 2. Auto Stamp Machine

This stage is the process of dividing and developing tool designs. Where in making the design of the automatic stamp machine using references or guidelines in accordance with the designs that have been made before.

The process of making the tool design will be divided into 3 stages, which are start machine, stamping machine, and exit machine.

1. Start Machine

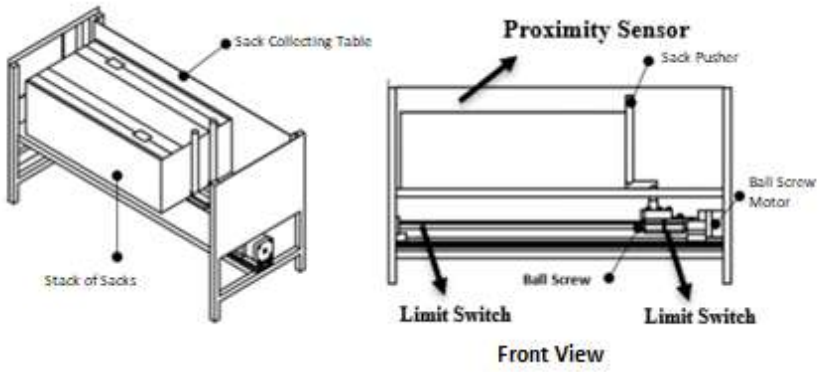

Fig 3. Start Machine

The starting machine functions as an initial shelter for sacks to be stamped which will then be inserted into the stamping machine. The initial process on the starting machine is where the operator places a pile of initial storage sacks. When the operator places a pile of sacks on the table, the proximity sensor will detect to make sure whether there are sacks before the machine starts. After making sure that the sacks are in the correct position, the operator needs to press the "START" button on the HMI to push the pile of sacks into the stamping machine with a ball screw driver driven by a three-phase motor. After the sacks have been loaded into the stamping machine, the ball screw pusher will move back to its initial position and then the operator can place a pile of sacks to prepare for the next batch of stamping.

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2. Stamping Machine

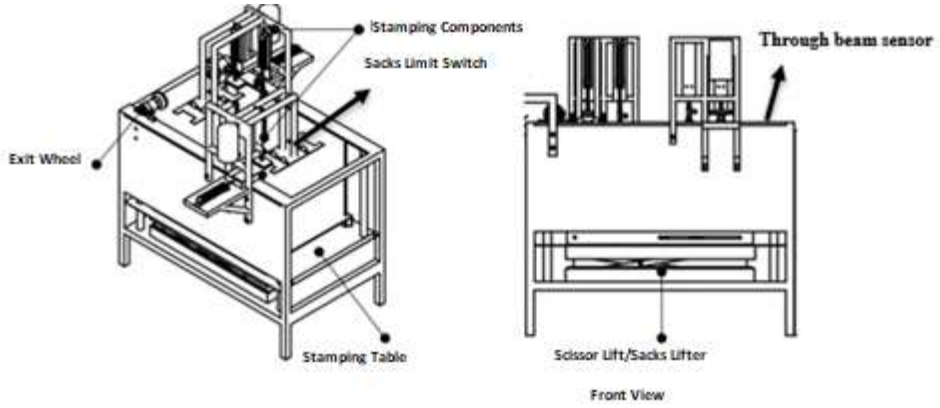

Fig 4. Stamping Machine

After the sacks enter the fitting section, the container table will be lifted up by a scissor lift driven by a servo motor to press down on the sack holders. After it is considered to be in its proper position, the lifting vacuum (2 sides) moves down to lift some of the sack folds. Furthermore, the folding roller wheel will move forward to unfold the sack (2 sides) and the lifting vacuum will be in the OFF position, moving up to its original position. The stamp tool which is driven by a pneumatic cylinder moving vertically (down to the bottom) performs the stamping on both sides of the sack. The final stage of the sack is continued by the exit wheel to the exit conveyor, and the stages for each sack will take place continuously starting from the vacuum lifting the folds until the sacks go to the conveyor exit and the scissor lift will move upward gradually and press on the sack holder until the pile of sacks has been stamped.
.

In this stamp machine there are main components which have several functions each to carry out the sack stamping stage, here is a close look at the design:

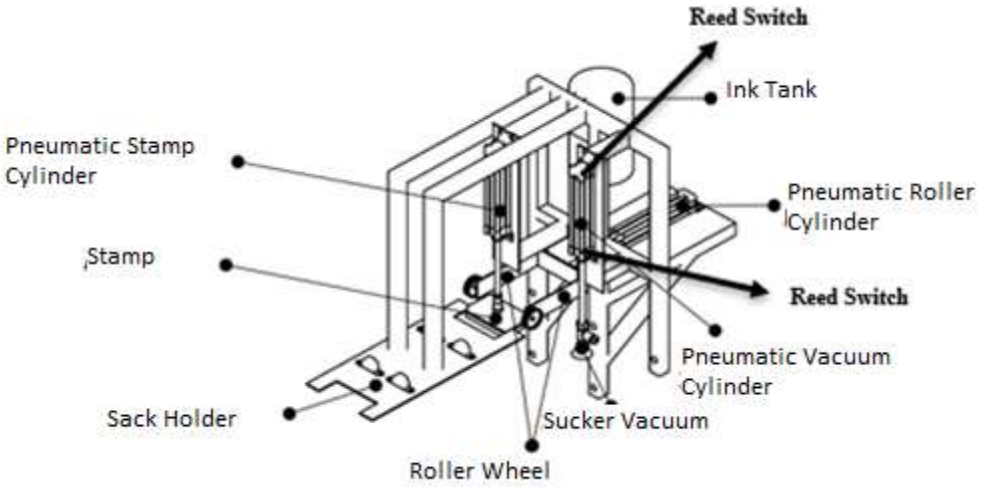

Fig 5. Pneumatic System Components

3. Exit Machine

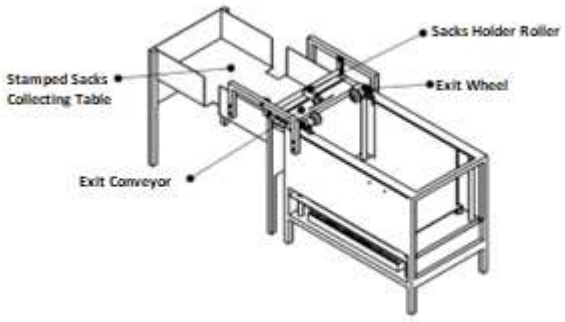

Fig 6. Exit Machine

After the sealing is complete, the sack is moved and forwarded by the rotating exit wheel to the exit conveyor. The sacks are held by the sack holding wheels on the conveyor and the exit conveyor rotates to help the sacks go to the final shelter. At the final shelter, there is a proximity sensor that is used to count the number of sacks that have been processed.

3.2 Pneumatic System Design

The Pneumatic system on Auto stamp consists of several types of components detailed in table 1

Table 1. Pneumatic Components in Auto Stamp

No	Komponen	Jumlah
1	Silinder Pneumatik *Single Acting* 10mm *Bore* 100mm *Stroke*	4
2	Silinder Pneumatik *Double Acting* 10mm *Bore* 100mm *Stroke*	2
3	*Vacuum Suction Cup*	2
4	*Vacuum Suction Nozzle*	2
5	*Solenoid Valve* 3/2 *way*	6
6	*Solenoid Valve* 5/2 *way*	2
7	*Magnetic Reed Switch*	12

From the components described above, a pneumatic circuit diagram is made using the FluidSIM software as shown in Figure 7. [8] [9]

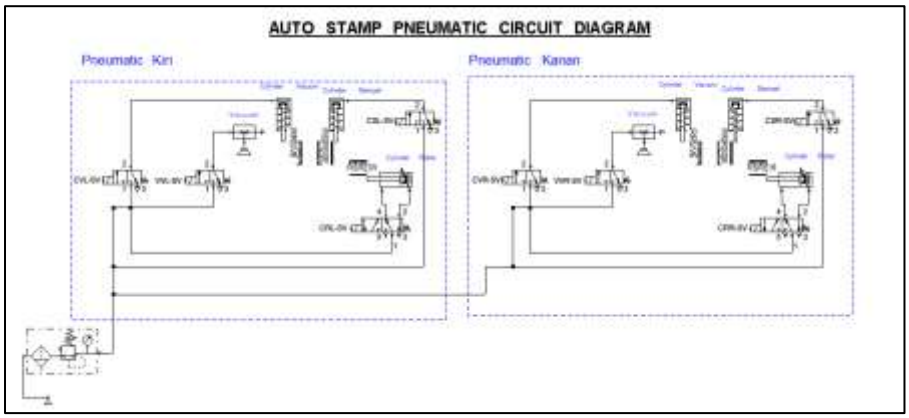

Fig 7. Pneumatic Circuit Diagram of Auto stamp

3.3 PLC I/O Adressing

In table 2. is the allocation of input-output addressing of the Auto stamp control system.

Table 2. Auto stamp I/O Adressing

Tag	Equipment	Component	Symbolic Address	D INPUT			D OUTPUT		
MS	Stamping Table	Limit Switch Sack	MS-LSK	I	0	0			
		Through Beam Sensor Sack Receiver	MS-TBR	I	0	1			
PB_E	Push Button Emergency	Push Button	PB_E	I	0	2			
MPA	Intake Table	Proximity Sensor Sack	MPA-PS	I	0	3			
MBS	Motor Ball Screw	Contactor Motor Forward	MBS-MCF				Q	0	0
		Contactor Motor Backward	MBS-MCB				Q	0	1
		Feedback Contact Forward	MBS-FCF	I	0	4			
		Feedback Contact Backward	MBS-FCB	I	0	5			
		Limit Switch Forward	MBS-LSF	I	0	6			
		Limit Switch Backward	MBS-LSB	I	0	7			
CVR	Cylinder Vacuum Left	Solenoid Valve 3/2	CVR-SV				Q	0	2
		Reed Switch Ext.	CVR-RSE	I	1	0			
		Reed Switch Ret.	CVR-RSR	I	1	1			
VVR	Vacuum Valve Left	Vacuum Valve	VVR-SV				Q	0	3
CRR	Cylinder Roller Folder Left	Solenoid Valve 5/2	CRR-SV				Q	0	4
		Reed Switch Ext.	CRR-RSE	I	1	2			
CSR	Cylinder Stamp Left	Solenoid Valve 3/2	CSR-SV				Q	0	5
		Reed Switch Ext.	CSR-RSE	I	1	3			
CVL	Cylinder Vacuum Left	Solenoid Valve 3/2	CVL-SV				Q	0	6
		Reed Switch Ext.	CVL-RSE	I	1	4			
		Reed Switch Ret.	CVL-RSR	I	1	5			
VSL	Vacuum Valve Left	Vacuum Valve	VVL-SV				Q	0	7
CRL	Cylinder Roller Folder Left	Solenoid Valve 5/2	CRL-SV				Q	1	0
		Reed Switch Ext.	CRL-RSE	I	2	0			
CSL	Cylinder Stamp Left	Solenoid Valve 3/2	CSL-SV				Q	1	1
		Reed Switch Ext.	CSL-RSE	I	2	1			
ME	Motor Exit	Motor DC 24V Left	ME-R				Q	2	0
		Motor DC 24V Left	ME-L				Q	2	1
CE	Conveyor Exit	Motor DC 24V	CE-M				Q	2	2
		Infrared Sensor Sack	CE-IRR	I	2	2			
MPE	Exit Table	Proximity Sensor (Counter)	MPE-PS	I	2	3			
TTR	Tank Ink Left	Liquid Level Sensor Low	TTR-LV	I	2	4			
		Lampu Indikator Low Level Left	TTR-BL				Q	2	3
		Left							
TTL	Tank Ink Left	Liquid Level Sensor Low	TTL-LV	I	2	5			

		Lampu Indikator Low Level Left	TTL-BL				Q	2	4
MSL	Motor Scissor Lift	Limit Switch Up	MSL-LSU	I	2	6			
		Limit Switch Down	MSL-LSD	I	2	7			
MS	Stamping Table	Through Beam Sensor Sack Transmitter	MS-TBT				Q	2	5
CRR	Cylinder Roller Folder Left	Reed Switch Ret.	CRR-RSR	I	3	0			
CSR	Cylinder Stamp Left	Reed Switch Ret.	CSR-RSR	I	3	1			
CRL	Cylinder Roller Folder Left	Reed Switch Ret.	CRL-RSR	I	3	2			
CSL	Cylinder Stamp Left	Reed Switch Ret.	CSL-RSR	I	3	3			

3.4 Wiring Diagram Drawing

The making wiring diagram consists of PLC and HMI communication wiring, CPU wiring, and I/O Module wiring. The sensors and actuators tag is written as the name of the component followed by the equipment where the component is located, such as “Reed Switch Extend CRL” it means it is a reed switch to indicate extend position on left roller cylinder (CRL).

- PLC and HMI Wiring

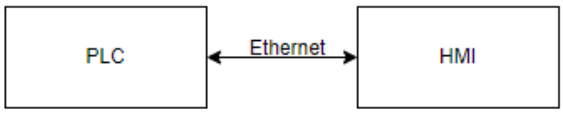

Fig 8. Wiring Power Supply

- Wiring CPU

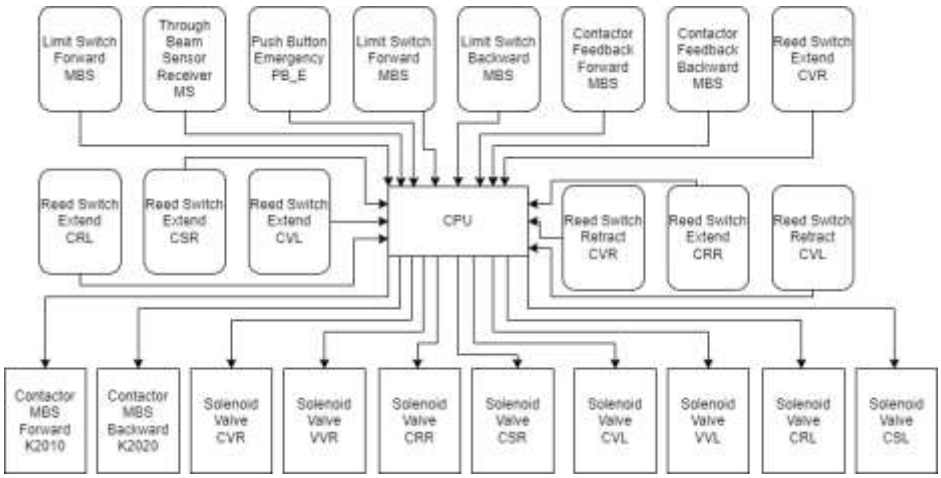

Fig 9. CPU, Sensors, dan Acuators Wiring

- Wiring Modul I/O

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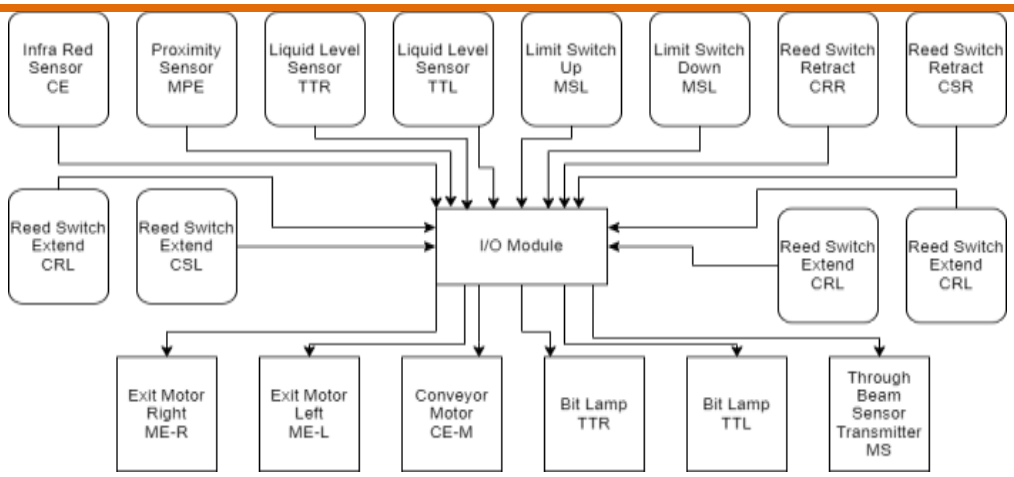

Fig 10. I/O Module, Sensors, dan Aktuators Wiring

3.5 PLC Programming

Making the PLC program for the control system on Auto stamp is done with the TIA Portal V17 software using the Function Block Diagram (FBD) programming language. PLC programming includes manual and auto programs. The manual program allows the operator to manually operate individual components. While the auto program allows the operator to carry out the entire Auto stamp work process by simply pressing two buttons. [10] [11]

Auto programming is divided into 3 stages, namely the intake stage, the stamping stage, and the exit stage.

• Intake Stage

A. Flowcharts

The auto intake stage on Auto stamp will be programmed according to the flowchart that has been made as follows.

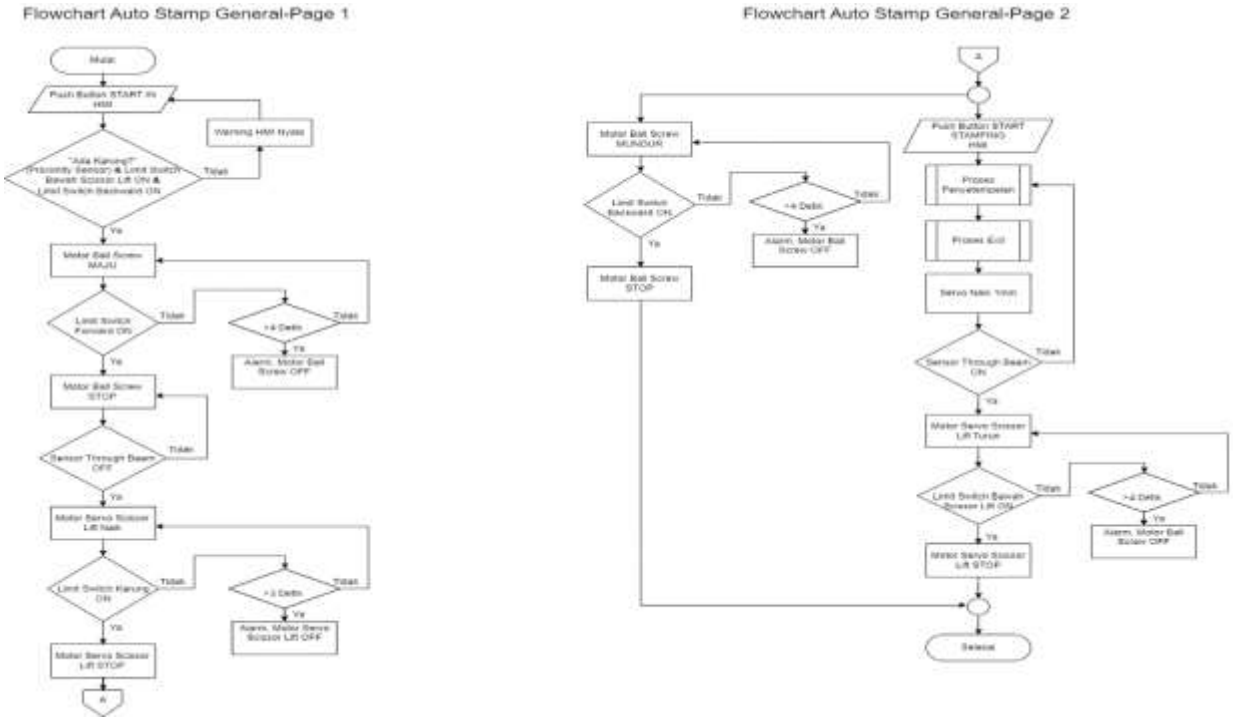

Fig 11. Auto stamp General and Intake Flowchar

When starting the operation. The operator needs to place a pile of sacks first on the initial collection table. When the sacks have been placed, the operator presses the START IN button on the HMI to start the intake operation. The proximity sensor will be ON

when it detects that there is a sack, and the limit switch under the scissor lift and the backward ball screw limit switch ON indicates that the equipment is ready in position so that the ball screw motor can advance.

Furthermore, the ball screw motor will stop after hitting the forward limit switch. The ball screw motor is designed to move forward and backward for 3 seconds, so if it is above 4 seconds the forward limit switch is not ON then it will alarm.

The thorough beam sensor on the stamping table detects that the sack is in its position in the scissor lift, so the scissor lift motor rises and will stop when it is hit by the sack's limit switch. The scissor lift motor is designed to move up for 2 seconds, so if it is above 4 seconds the sack limit switch is not ON then it will alarm.

Then, the ball screw motor will move backwards to the initial position and will stop when it hits the backward limit switch. The ball screw motor is designed to go backwards for 3 seconds, so if it is above 4 seconds the forward limit switch is not ON then it will alarm.

Once the intake is complete, the operator needs to press the START STAMPING button on the HMI to proceed to the stamping process.

• Stamping Stage

A. Flowcharts

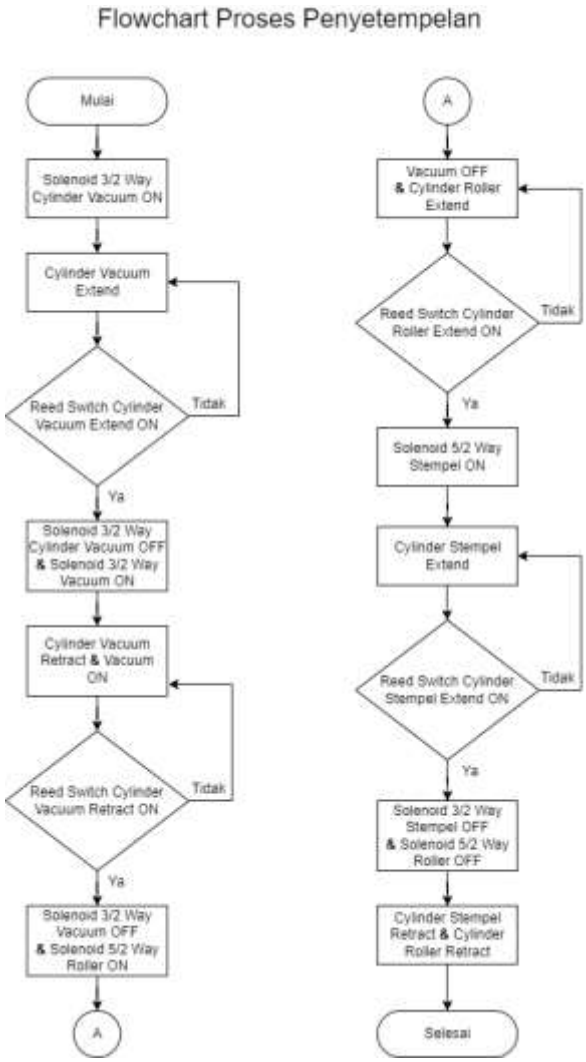

Fig 12. Stamping Process Flowchart

When the sacks that have been stamped are used up, the through beam sensor will activate because it is no longer obstructed by piles of sacks. The through beam MS-TBR will trigger STAMPING_OVER to notify that the stamping process is complete and instruct the scissor lift to go down. STAMPING_OVER will RESET the auto AUTO_STAMPING_OUT command.

• Exit Stage

A. Flowcharts

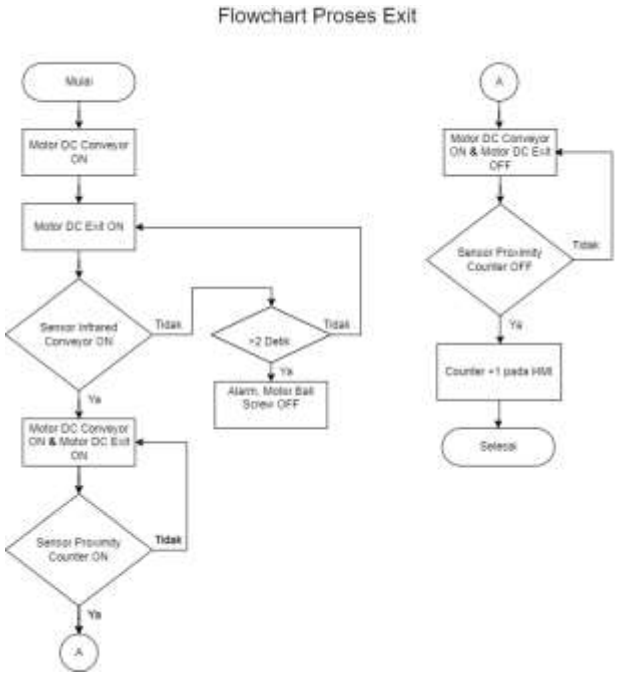

Fig 13. Exit Process Flowchart

3.6 HMI Design

In the HMI design that is made, the active component will be visualized by displaying a green color on the component. In this HMI design there are three buttons to operate the machine, namely the AUTO button to start machine operation, the STOP button to stop machine operation and reset the sack count, and the EMERGENCY button to stop machine operation in case of an emergency. The HMI also displays the number of stamped sacks. [12]

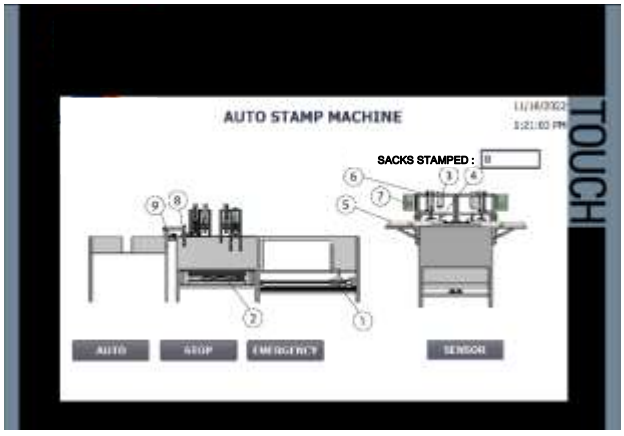

Fig 14. Overall HMI Design

When the AUTO button is pressed to start engine operation, the ball screw driving component (1) will be active in green. After the sacks have been pushed into the stamping table, the scissor lift (2) will raise the pile of sacks to be stamped and colored green. After the sack touches the sack limit switch on the stamping table, the vacuum cylinder (3) will extend to lift the sack fold and will turn green. When the vacuum suction cylinder (4) has fully extended, the vacuum will activate to pull the sacks and will turn green. When the vacuum cylinder retracts again and the vacuum suction (4) turns off, the roller cylinder (5) will extend and turn green to fully

unfold the sack, then continue with the stamp cylinder (6) to extend and green to seal the sack with the feed type label contained in the sack, then the roller cylinder (5) and the stamp cylinder (6) retract. Then when all the cylinders retract, the exit motor (8) and the conveyor motor (9) will be active and green to eject the stamped sacks to the final sack collection table. The proximity sensor that is placed on the final sack collection table will detect how many sacks have been stamped and also functions to stop the motor exit (8). The number of sacks that have been stamped will be displayed on the HMI in the "SACKS STAMPED:" box in the upper right corner of the HMI.

A liquid level sensor is installed on the ink tank (7) to indicate that the ink is still full or has run out which is indicated by a green or red bit lamp.

The STOP button is used to stop machine operation and reset the sack count and the EMERGENCY button is used to stop machine operation in case of an emergency.

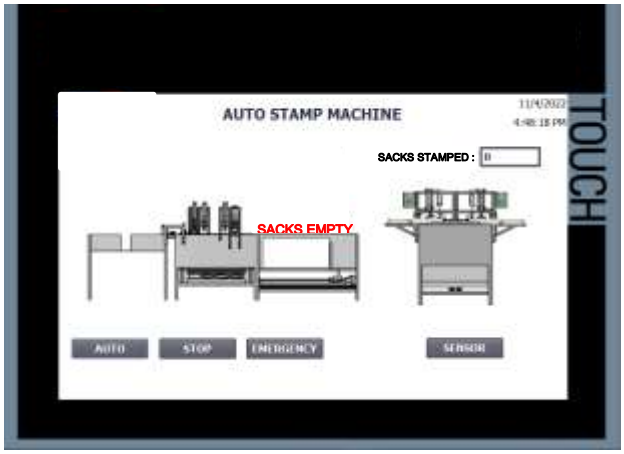

Fig 15. Empty Sack Warning HMI Design

If sacks are not detected by the proximity sensor on the initial sack collection table, the ball screw (1) pusher cannot be activated and the HMI will issue a warning in the form of the words “SACK EMPTY" in red.

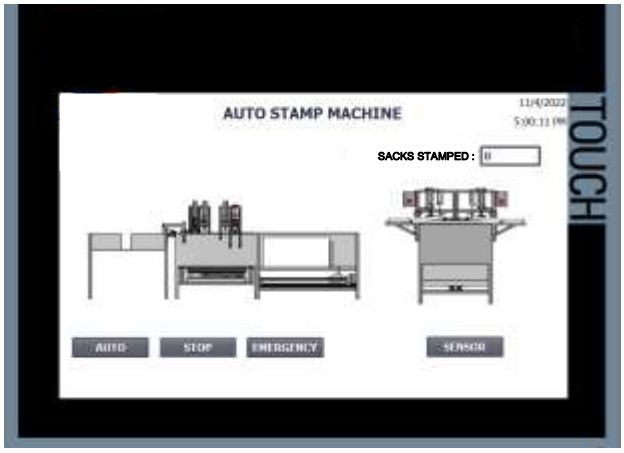

Fig 16. Out of Ink Warning HMI Design

When the ink in the tank runs out, the bit lamp on the tank will turn red.

4. DISCUSSION OF RESULTS

During the internship activities, the authors carried out project initiatives as a form of solution to problems that occurred in the company. With this the authors carry out the design of an automatic stamp machine design with an electro-pneumatic system which can be seen as follows.

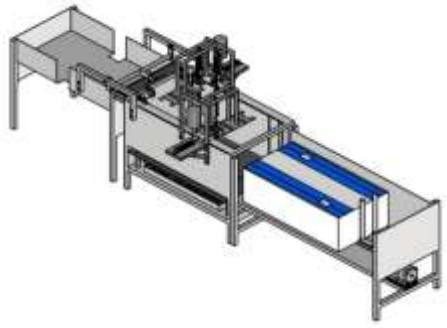

Figure 17. Automatic Stamp Machine Design

The automatic stamp machine is designed to be able to process stamps with a capacity of 500 packaging sheets per batch and takes 75 minutes for each batch. The target of this machine is to produce 9,000 sheets of stamped product packaging in a day so that in a yearly calculation (300 days) it can produce 2,700,000 pieces of product packaging.

5. CONCLUSION

1. Industrial automation is needed to produce manufacturing speed and efficiency in the midst of intense global business competition.

2. The industrial automation project that the author applied to production problems is to design an Auto stamp machine for the efficiency of the process of stamping feed type labels on feed sacks.

3. With the Auto stamp Machine, the capacity of the sack-stamping production process per day increases to 9,000 sheets compared to the manual method which is only 7,800 sheets.

4. The Auto stamp machine is controlled using a PLC and can be monitored and operated through the Human Machine Interface (HMI) by the operator.

6. REFERENCE

[1] A. Gundawar. (2017). “Pneumatic Stamping Machine,” Mech. Eng., no. 3, pp. 1558–1564, 2017.
[2] U. S. River. (2005). “Phase I: Mechanization and Rationalization of Labor,” Automation, pp. 122–126.
[3] A. Patil, Y. Risodkar, M. Paliwal, and R. Gadhave. (2018) “"Automatic Stamping Machine ",” Int. J. Innov. Sci. Res. Technol., vol. 3, no. 5, pp. 3–5.
[4] Oladapo, Bankole I. et al. (2017). “Experimental Analysis of Electro-Pneumatic Optimization of Hot Stamping Machine Control Systems with on-Delay Timer.” *Journal of Applied Research and Technology* 15(4): 356–64. http://dx.doi.org/10.1016/j.jart.2017.03.006.
[5] S. T. C. Pamungkas Adji Krisna Dikza. (2017). “Rancang Bangun Mesin Pencetak Batik Cap Semi Otomatis Dengan Menggunakan Sistem Elektro-Pneumatik,” pp. 1–120.
[6] A. PARR. (2003). Hydraulic and Pneumatic S a Technician’ and Emgineer’S Guide.
[7] Siemens AG. (2015) “SIMATIC S7-1200 Easy Book Manual,” p. 454.
[8] Subagio, Djoko. “Design Control System of Name Plate Date Stamping Machine Based on PLC in Automotive Manufacturing Industry.”
[9] Sutisna, Nanang Ali, and Reza Alfarisi Firmansyah. (2019). “*Design of Automatic Stamping Machine for Date and Dash Code Marking Using Pneumatic System and PLC Controller.*” *Journal of Mechanical Engineering and Mechatronics* 3(1): 40.
[10] Victor Haryanto, Edy et al. (2014). “Perancangan Alat Stempel Otomatis Lembar Jawaban Stmik Potensi Utama.” *Seminar Nasional Informatika*.
[11] Rizqi, Muhammad Alif. (2016). "*Rancang Bangun Mesin Stamping Part Number Otomatis Pada Kampas Rem Menggunakan Sistem Elektropneumatik"*. Diploma thesis, Politeknik Perkapalan Negeri Surabaya.
[12] Normanyo, Erwin et al. (2014). “Developing a Human Machine Interface (HMI) for Industrial Automated Systems using

Siemens Simatic WinCC Flexible Advanced Software."

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