Acta Tecnología - International Scientific Journal about Technologies
Volume: 9 2023 Issue: 1 Pages: 35-38 ISSN 2453-675X

https://doi.org/10.22306/atec.v9i1.166 Received: 23 Feb. 2023; Revised: 10 Mar. 2023; Accepted: 28 Mar. 2023

Design of an automated plastic bag packaging machine

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Keywords: plastic bags, prototype, packaging, machine design.
Abstract: Thin plastic bags are common in Vietnam's sweets and food stores. Currently, due to the need to preserve dried goods, the majority of these items will be stored in fully sealed plastic bags. In order to improve package efficiency, design, and eliminate packaging errors, a completely automatic packaging machine is required to assure safety and cleanliness, enhance performance, and enhance the aesthetics of packaging designs. The study provided an approach for designing a prototype of plastic bag product packaging. Use the SolidWorks to design, analyse, and select materials based on machine concept. Then, an electrical and pneumatic system was constructed, followed by the fabrication and testing of a prototype to demonstrate the validity of the model.

1 Introduction

Thin plastic bags are common in Vietnam's sweets and food stores [1,2]. Currently, due to the need to preserve dried goods, the majority of these items will be stored in fully sealed plastic bags [3,4]. In order to improve package efficiency, design, and eliminate packaging errors, a completely automatic packaging machine is required to assure safety and cleanliness, enhance performance, and enhance the aesthetics of packaging designs [5,6]. This topic combines numerous needs for an automated packing system. The packing machines function precisely, swiftly, and in the correct quantity and volume. Consequently, decreasing the loss of raw materials, thereby minimizing expenses. Packaging machines have been in Vietnam for a very long time; the majority of them are very advanced foreign machines; however, the cost of acquisition, maintenance, and operation is considerable [7,8]. Every day, the demand for packing dried goods for distribution on the market grows. The primary objective of the study is to design a product packaging machine system. Utilizing Solidworks software to design, test, and pick materials for details based on machine design theory, then, a PLC system is selected for machine operation design [9,10]. This machine was designed to increase worker productivity and enhance job efficiency.

2 Methodology

2.1 Plastic packaging machine overview

Product packaging machine refers to a packaging machine that is automatic in the production process, automatically packing, automatically measuring, weighing, measuring, and automatically closing with the highest degree of precision [11,12].

Bring efficiency to production and complete packaging. Human effort is used to replace manual product packing with packaging machines. The packing of food and other items is facilitated and accelerated by production assistance. Currently, all industrial and agricultural products are packed. In addition to preserving the goods, the packaging must also represent the brand and prevent counterfeiting.

2.2 Working principle

Figure 1 shown the preliminary design of the machine. The two most important parts of the machine are: container (3), welding rod (6). Hydraulic cylinders facilitate machine motion, The mechanism operates in stages: (1) click the Start button on the cylinder (2) to release it, and (2) activate the suction. Suction head sucking bag while cylinder (2) continues. The slider (1) transports the mounted mechanism into the weighing and packaging area. Cylinder (2) emerges, switches to the opposite side suction, and returns. The bag's mouth has been opened. The silo is unlocked by cylinder (3), the material is discharged into the bag, and the weight is measured by cylinder (7). When sufficient weight has been measured, cylinder (3) closes the silo discharge door. As the second cylinder (2) emerges, compress the bag's mouth. The extraction of cylinder (5) brings the welding mechanism into the packing area. Welding commences after the clamping cylinder (4) clamps two rods (6) with wire attached. At the conclusion of the welding process, cylinder (4) releases the clamp, cylinder (5) returns the mechanism to its original position,

and cylinder (6) closes the two suction valves. The cylinder (2) and slider 1 return to their initial positions.

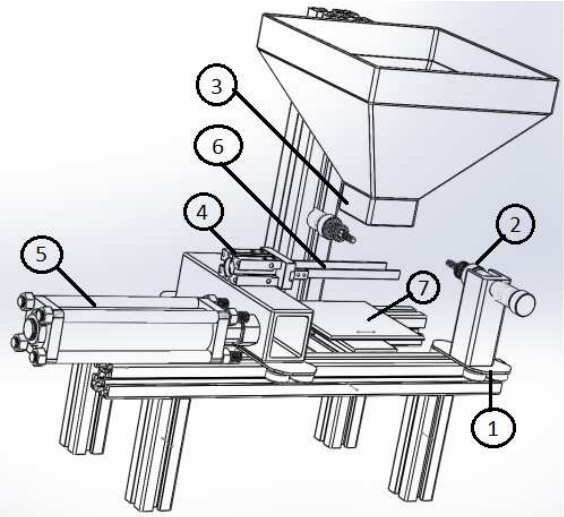

Figure 1 Overview of the packaging machine

2.3 System requirement

Table 1 summarizes the values used in the current work based on actual packaging requirements in Vietnamese manufacturing facilities for bags of dimension 3x4 with a maximum weight of 1 kilogram.

Table 1 System requirements

	Parameters	Requirements
1	Execution time of each cycle	< 60 second
2	Execution time for each step	< 20 second
3	Time delay	< 100 ms
4	Suction pressure	< - 0.03 Mpa
5	Bag size	3x4 cm
6	Mass product	0 – 1 Kg
7	Tolerance	0 – 1 Gram

2.4 Mechanical frame of machine

A machine frame must be robust and simple to attach and fasten with other components. Regarding bearing, it must be robust and rigid enough to support the weight of other details, primarily bending. Table 2 shown the mechanical properties of the 6063S aluminum employed in this study. The frame is constructed using aluminum shapes as shown in the Figure 2.

Table 2 Material properties of frame

Mass Density	Poisson's Ratio	Tensile Strength	Yield Strength
2700 kg/m^3	0.33	90 Mpa	50 Mpa

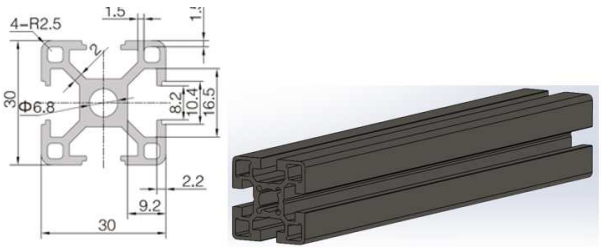

Figure 2 Shaped aluminium dimension

Other machine elements attached to the frame are estimated to weigh 5 kg. Figure 3 displays the results of a strength test performed on the frame using the Soliwork software. After ensuring the frame's durability, a prototype is built.

Figure 3 Frame of machine

2.5 Design electrical system

As seen in Figure 4, the system employs a Mitsubishi FX1N-60MR PLC with 36 Digital inputs and 24 Digital outputs; the PLC's power supply can be set to either220V.AC or 24V DC. Group of nine pneumatic valves DV3220 with DR100-5 suction wire were used.

Figure 5 shown the Display interface, the control panel mimics that of an external hardware controller. Output statistics and system error reports are also displayed. The monitor clearly displays the current program step, PLC error reporting, and output data. The test screen contains cylinder control buttons that display the operational state of the cylinder.

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Figure 4 Electrical system

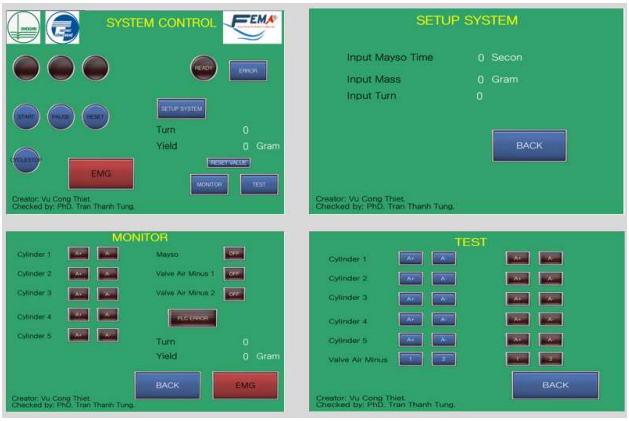

Figure 5 Display interface

3 Results and discussion

Figure 6 depicts the construction of a basic, inexpensive prototype for system testing, with components made from readily available materials.

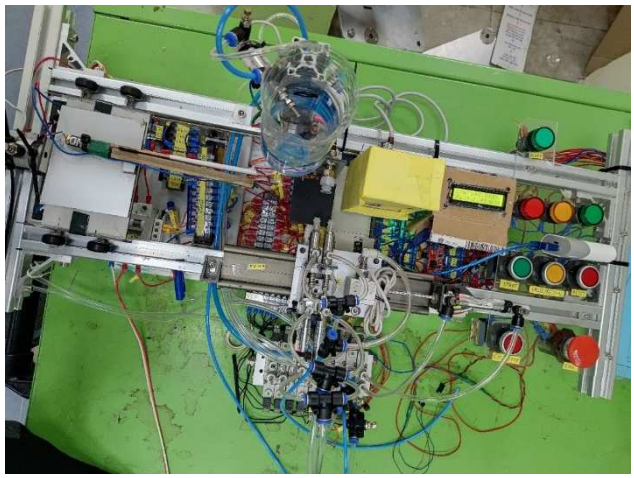

Figure 6 A prototype of machine

The structure satisfies safety requirements and does not vibrate or deform during operation. With the PLC controller, the system operates smoothly in terms of operating modes, indicator signals, and safety requirements.

Figure 7 Load cell and Suction pressure test

The Figure 8 shown the load cell and suction pressure test. The weighing model functions precisely, the error is within the acceptable range, and the signal is sent to the PLC correctly. The Scada monitor screen functions properly, has the ability to issue control commands as if they were genuine external physical keys, the step-by-step monitoring interface is clearly displayed, and each system element's function can be tested an error message is displayed when the period of each step exceeds the set time and the PLC error.

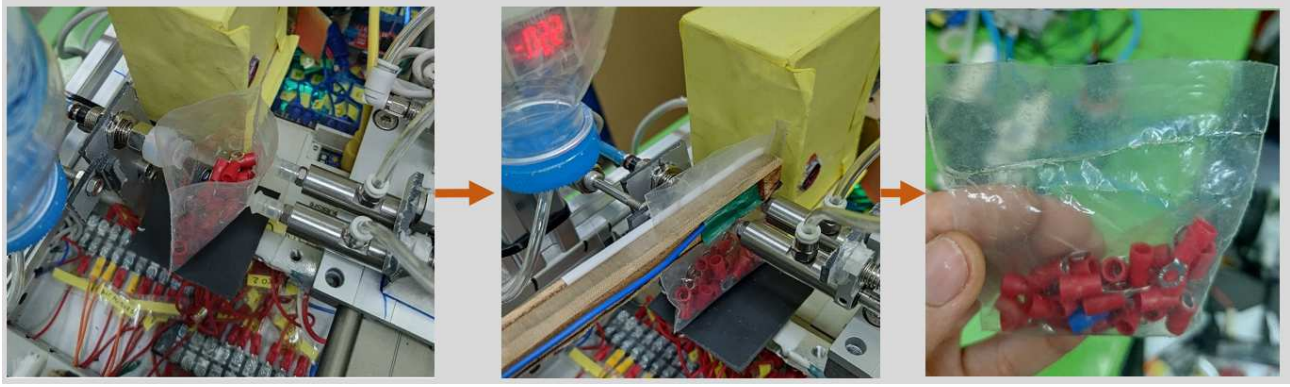

Figure 8 Experimental test

The processing time under normal conditions is approximately 45 seconds. From the stage of opening the bag's mouth with suction pressure to the stage of closing the plastic bag and releasing the completed product as shown in the Figure 8. There is a 50-70 millisecond time delay under standard working conditions. This is an acceptable level based on the design specifications (<100 ms). The pneumatically system worked properly, and the suction pressure is satisfactory for bag opening and closing.

Table 3 Comparison design requirements and experimental results

Parameter	Requirement	Experimental test
Time cycle	< 60 second	45 second
Time delay	< 100 ms	50-70 ms
Bag size	3x4 cm	3x4 cm
Error weighting	0-1 gram	0.16 gram

The majority of the initial factors, such as bag size, weight, and time, are satisfactory, as shown in Table 3's comparison of initial design requirements and experimental results. Thus, the design prototype satisfies the specifications and can be utilized in actual production. However, the prototype's lack of attractive appearance is a result of its extensive use of readily available materials in an attempt at cost savings.

4 Conclusions

The study presented a prototype for the packaging of plastic bags. The machine was designed and meets the mechanical and electrical requirements. The product is equipped with components such as vacuum, load cell, and a heating part in order to facilitate the packaging process. The prototype functions effectively to ensure that the design requirements are exceeded, and this model is also manufactured at a lower cost than comparable machines. In addition, the proposed prototype can serve as a dependable reference for the future development of improved packaging machines for Vietnam. Future works may involve designing electrical cabinets and product storage systems to enhance the attractive appearance of products. In addition, the vacuum system must be improved so that the machine can be used with bags of various sizes.

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