Journal of Engineering Mechanics and Machinery (2023)
Clausius Scientific Press, Canada

DOI: 10.23977/jemm.2023.080310
ISSN 2371-9133 Vol. 8 Num. 3

Design of an Automatic Packaging Machine for Syringes

Hao Tan, Ximei Li

Wuhan Huaxia Institute of Technology, Wuhan, China

Keywords: Syringe, automatic packaging, heat sealing, cylinder, servo control

Abstract: The 5ml syringe automatic packaging machine designed in this paper is mainly composed of mechanical structure and control system. The machine is based on the traditional vertical packaging machine, syringe automatic packaging machine can complete the syringe from the clutter of syringes to achieve a single sequential packaging, can achieve the whole process from feeding, film forming, and then the bag heat sealing, shear. The feeding is achieved by vibrating discs, the heat sealing device is controlled by a cylinder heat sealing jig to seal the plastic film longitudinally and horizontally, and the serrated blade is used to cut, the whole machine is compact and easy to install and manipulate. The packaging machine is highly automated, the user only needs to put the syringe into the vibrating plate, through the machine's servo control, can achieve a key start, but also through the adjustment of the software parameters to achieve control of the syringe packaging speed.

1. Introduction

Syringes are a relatively common medical appliance, syringe automatic packaging machine is a special automatic syringe packaging machine, the previous encapsulation of syringes mostly by hand, there is low efficiency, prone to human interference and other problems, so the demand for automatic encapsulation device was born[1]. The current packaging method for disposable syringes is usually that the rolled plastic film has to be cut into several bags before the cut bags are placed on the sealing machine for heat sealing, which then has some problems such as instability and unreliability, as they also have to be placed manually, which can cause contamination during the sterilisation process, thus affecting the hygienic quality of the syringes in the bags and also the work efficiency, it is therefore necessary to modify the current automatic packaging machines for syringes. Due to the development of the pharmaceutical industry, the requirements for syringes are becoming higher and higher, and the use of syringe packaging equipment is increasing.

At present, China already has automatic packaging machines for syringes, most of which are packed in a mechanical way, but their production efficiency is low and their operation is difficult. In the continuous use of electronic technology and computer technology, automatic syringe packaging machine has gradually reached the degree of electronic, intelligent and automated[2].This makes it significantly more efficient. This has resulted in a significant increase in efficiency and a significant reduction in the difficulty of work, resulting in a significant increase in efficiency and quality of packaging[3]. The development and use of a fully automatic packaging machine for syringes will help the pharmaceutical industry to develop and operate. The research, development and use of automatic packaging machines for syringes will help the development and operation of the pharmaceutical industry, thus enhancing the production efficiency of the pharmaceutical industry, improving the

quality and safety of medicines, and enhancing the brand image and market competitiveness of the pharmaceutical industry.

The most common industrial control products are PLC, frequency converter, etc. In China, packaging machines are more often used with PLC control systems. Compared with other control systems, PLC control systems have high reliability, strong anti-interference ability and good flexibility, so they are widely used in the field of packaging machinery automation[4]. Packaging machinery control system must follow and seize the opportunity of scientific and technological innovation, the development of China's packaging machinery, control automation, intelligent technology and other areas of life control system innovation, and the latest scientific and technological achievements gradually applied to machinery and equipment construction and production industry[5].

2. Solution Justification for Syringe Packaging Machines

The movement of the syringe packaging machine is a smooth, sequential packaging process. Firstly, it uses a speed-controlled motor to control the vibratory feeding of the vibrating disc, which turns the syringes into individual sequential feeds. The motor drives the film feeding device to feed the film and the belt pulling device to pull the belt. Different motors correspond to different treatments, and the speed of the film feeding and the speed of the belt pulling are matched so that the packaging can proceed in a coordinated, stable and error-free manner. The packaging film of the automatic packaging machine is mounted on an axial roller. The items to be packaged are sent to the part of the bag-making shaper by the feeding conveyor belt, at which point the packaging film is fed by the film feeding device into the bag-making machine for bag-making, and the shaper will make a piece of film into a column. After the syringe enters the slide, it is fed into the program and is firstly sealed horizontally and vertically by the cylinder. The horizontal sealing process will heat seal the lower end of the bag so that the syringe falls into the bag and not out of the columnar bag. Figure 1 shows a sketch of the automatic syringe packaging machine mechanism.

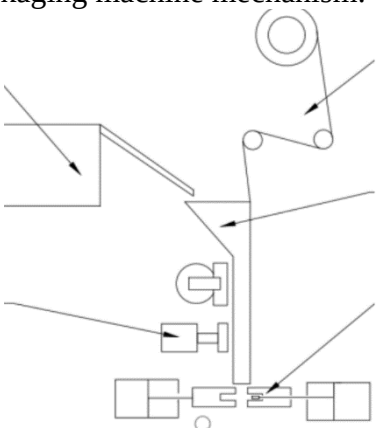

Figure 1: Sketch of the automatic syringe packaging machine mechanism

3. Syringe Packaging Machine Mechanical Structure Design

The basic devices of the automatic syringe packaging machine are mainly: feeding transfer mechanism, film feeding mechanism, bag making and forming machine, heat sealing and cold cutting mechanism, belt pulling mechanism, etc.

3.1. Feeder Transfer Mechanism

The main device for feeding material is the vibrating plate, which is widely used in packaging machinery, mostly to make a pile of scattered materials automatically sorted and transferred out[6]. The vibrating plate consists of an electromagnet, a frame, a spiral vibrating disc, a vibration damping pad and a feeding port. The object is moved by the twisting pendulum and can rise through the spiral vibrating disc and finally can rise to the outlet. The vibrating disc is an automated, directional sorting machine. Figure 2 shows bucket type electromagnetic vibratory feeder.

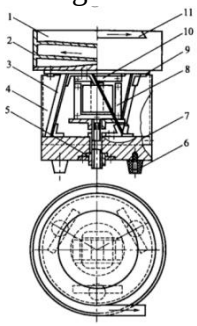

Figure 2: Bucket type electromagnetic vibratory feeder

The diameter of the hopper can be selected in a wide range, small ones mostly use cast aluminium parts, large ones mostly use stainless steel plate welded parts or plastic injection moulded parts. The spiral vibrating disc is fixed by the main vibrating plate, which can keep the main body stable and maintain a relatively low mass. The orientation of the electromagnet should be in an inclined direction in order to ensure the normal operation of the work, and the speed of supply needs to be kept within a certain range, especially for materials made of metal, while the rate of discharge should also be controlled in this design, in conjunction with the heat sealing rate at the back. The electromagnetic vibratory feeder in this design is shown in Figure 3.

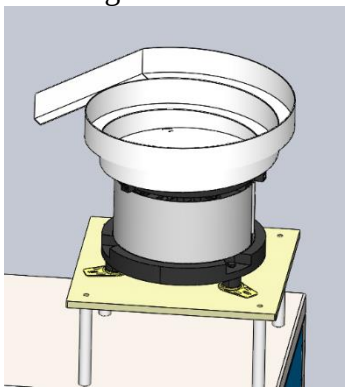

Figure 3: Electromagnetic vibratory feeder

3.2. Film Feeding Mechanism

On the automatic packaging machine, the film transport device generally includes: film winder tension adjuster、film tray、film winder. The film winder tension adjuster adjusts the film winder tension to keep the film consistent when transported on the automatic packaging machine and to prevent the film winder tension from becoming loose or tight. Film carrier is a material storage film carrier, installed in the automatic packaging machine or side; film winder is a device to roll the film.

Automatic packaging machine in the film conveying device, the principle of the device is the roll of packaging film into the working area of the packaging machine to facilitate packaging operations.

The film roll is first stretched to a degree by a tension control device to ensure that the film remains flat and does not slacken during the wrapping process, and is then passed through a series of guiding devices to keep it in the correct direction for the next step. The film feeding device is shown in Figure 4.

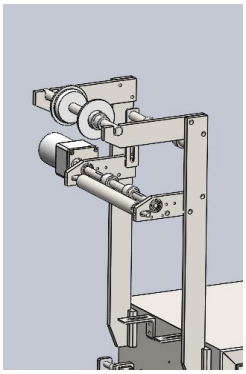

Figure 4: Film feeding mechanism

Packaged in OPP (polypropylene), the advantages of using OPP as syringe packaging are: because of the high light transmission of the OPP material, it enables the user to see the product better; secondly, the excellent physical and chemical properties of OPP provide better protection against permeation, oxidation and ultraviolet light; convenience: syringes made of OPP are easier to handle and the outer bag is easier to remove, improving the comfort and convenience of the user; durable, not easily broken and not easily distorted, extending the service life of the product.

3.3. Bag Formers

The bag former is a very important part of the packaging process, forming a plastic film into a cylinder and leaving the opening for the transfer syringe. The main component used in this design is the elephant trunk former, which is a very important part of the packaging process. The shape of the former is similar to an elephant's trunk, so that when the flat film passes through the former, the resistance is less than with other former, making it more fluid to use and not damaging the packaging film[7]The elephant trunk former has a key impact on the quality of the packaging. The elephant trunk shaper has a key influence on the quality of the packaging and has a certain influence on the size, shape and aesthetics of the finished product, and the packaging process needs to be considered when making the bags. The bag is first made into a cylinder with two overlapping sides by the shaper, then the bag is made into a cylinder with the vertical sealing device, then the bag is finally made into a finished bag by cross-sealing and cutting. The elephant trunk former is shown in Figure 5.

Figure 5: Elephant trunk shape

3.4. Heat Sealing and Cold Cutting Mechanism

The heat sealing of the packaging machine is firstly heated by the heating plate, which causes the temperature of the packaged plastic film to rise leading to melting or softening, and then it is given a certain pressure to make the two layers fuse together and form a heat seal. In this design, two identical layers of film are sandwiched together and sealed by heating. During the hot work of the packaging machine, the heated material is first placed on the heat sealing plate, then the heating of the plate causes the temperature of the material to rise, reaching the heat sealing temperature, and a certain pressure is applied through the hot air mechanism on both sides to bond the material together and form a seal. Finally, the middle part of the heat seal is cut away by means of a cutter. It should be noted in the design that the heat sealing temperature, heat sealing time and heat sealing pressure are the main factors affecting the heat sealing effect and need to be adjusted according to the type and thickness of the material at the time. During the heating process, the flatness and cleanliness of the material to be heat sealed should also be ensured to ensure the tightness, reliability and stability of the heat seal. A sketch of the cross-seal cold cutting unit is shown in Figure 6.

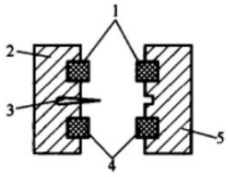

Figure 6: Sketch of the cross-sealing device

After the packaging has been heat sealed, the plastic film needs to be cut by means of a cutter. There are many different types of cutter, including straight cut, rotary and heat seal. In this design, a straight cutter is used, with a serrated blade. The cutter cuts the packaging material directly into the required shape, the cutter and the heat seal device are controlled by a cylinder for heat sealing, and when finished the cylinder movement through the control cutter. The sealing electrode is used to heat and determine the sealing pattern, the fixing plate is used to fix the blade and sealing electrode and the serrated knife is used to cut the heat-sealed bag. The design of the cross-sealing and cold cutting device is shown in Figure 7.

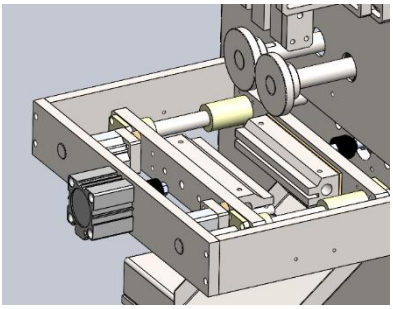

Figure 7: Diagram of the cross-seal cold cutting unit

3.5. Bag Pulling Mechanism

The belt pulling part is made up of a belt pulling wheel and a stepper motor. The fixed rotation speed and rotation distance of the stepper motor are controlled by the program to achieve control of the longitudinal stretching length of the packaging bag, in conjunction with the rate of film feeding action. The belt pulling mechanism is shown in Figure 8 and the overall unit is shown in Figure 9.

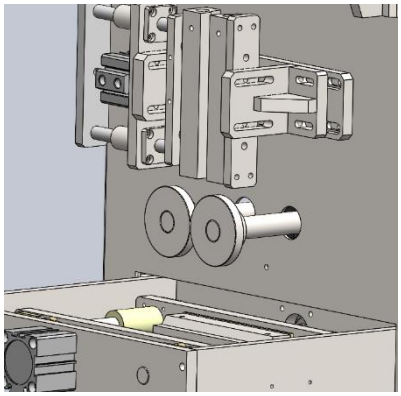

Figure 8: Taping device

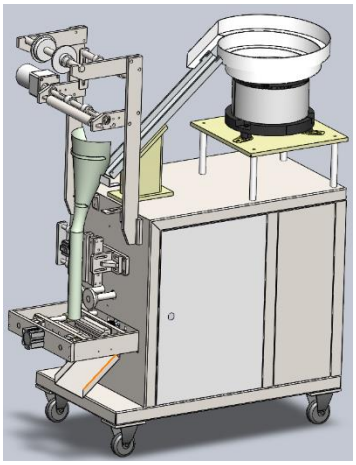

Figure 9: Diagram of the overall installation of the syringe

4. Control Section Design

4.1. Control Principle

The overall control system is determined according to the functional and performance requirements of the packaging machine, combined with the overall concept and working principle. The mechanical structure of the packaging machine, the overall control scheme diagram. The control section consists mainly of hardware design and software design. The hardware part first determines the selection of the control kernel, the type of input and output signals used in the control process, the selection of the control kernel PLC, the selection of various sensors and safety circuit components, the specific configuration of the control system, the rational allocation of the PLC input and output interfaces, and the construction of the hardware circuit[8]. The software part is mainly to write the packaging machine program and to debug the control system according to the actual working conditions.

There is one electromagnet for vibrating the vibrating plate, three cylinders for cross-sealing, longitudinal sealing and knife cutting, and two stepper motors for film feeding and belt pulling respectively. The control block diagram is shown in Figure 10.

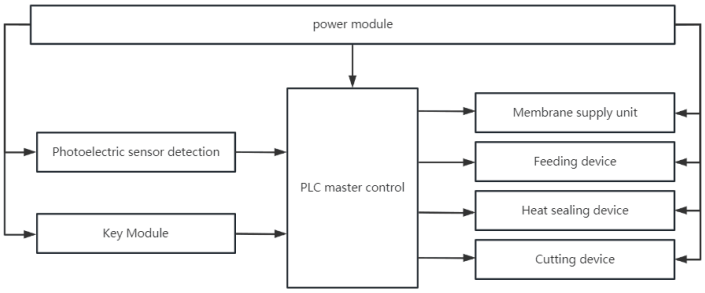

Figure 10: Control block diagram

After the power is connected, the vibrating plate starts to vibrate and feed the material, the syringes are transferred to the chute, the photoelectric sensor detects if there are syringes in the chute, if not, continue to detect, if there are syringes, start the horizontal sealing cylinder vertical sealing cylinder for heat sealing. After the hot air is finished, the cylinder for cross cutting is started for cutting. After the cutting is finished, the three cylinders are retracted and the film pulling motor is started to pull the belt motor to prepare the bag for the next time, a complete packaging process is finished. The control flow diagram is shown in Figure 11.

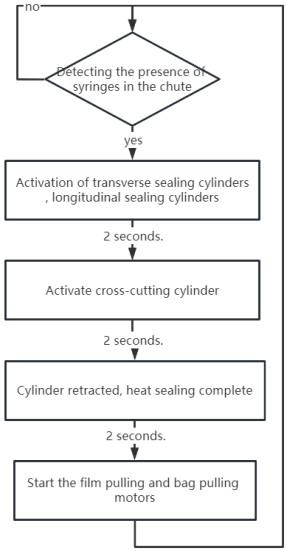

Figure 11: Control flow diagram

4.2. Pneumatic Circuit Design

The pneumatic circuit consists of a gas source, a two-way valve, a two-position five-way reversing valve, an adjustable one-way throttle valve and a double-acting cylinder[9]. One of the duplex keys consists of a filter (with diverter drain) and a pressure reducing valve[10]The air source first provides the compressed air. Firstly the air source provides compressed air, the air filter is used to purify the air so that the air can meet the standard used, a regulator is connected at the back to adjust the pressure of the incoming air, a pressure gauge helps to regulate the pressure. When the two-position five-way reversing valve is in the left position when it is powered, the cylinder is driven to the right and the adjustable one-way throttle controls the size of the cylinder and thus the speed of movement. And when the two-position five-way reversing valve is in the right position when the power is lost, the cylinder is in the reset. Cylinder control circuit as shown in Figure 12.

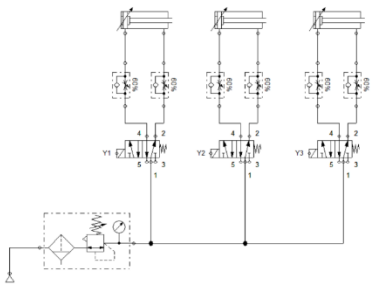

Figure 12: Cylinder control circuit

5. Conclusion

Automatic packaging machines are an important technological innovation in modern manufacturing. This thesis provides an in-depth discussion and analysis of the research and design of an automatic packaging machine for syringes, with the aim of providing guidance for further understanding and application in this field. The design was completed through a comprehensive assessment of the features, functions and performance of existing automatic packaging machines and the refinement of some of the shortcomings. The packaging machine has a packaging rate of 10-20 bags/minute and is suitable for various small and medium-sized enterprises. It is believed that through continuous exploration and innovation, the automatic packaging machine will continue to bring more efficient, flexible and sustainable production methods to the manufacturing industry, providing solid support for the development and competitiveness of enterprises.

Acknowledgements

1) This work is supported by the curriculum system of mechanical and electrical majors from the perspective of "double first-class" construction (Project No.: 2113).

2) This work is supported by Hubei Province Higher Education Outstanding Young and Middle-aged Science and Technology Innovation Team Program Project of Advanced design and manufacturing technology (Project No.: T201837).

3) This work is supported by Major in Mechatronics Engineering--New engineering major pilot project in Wuhan Huaxia Institute of Technology (Project No.: 2022110).

References

[1] Zhao Jinkang. Application and prospect of automation technology in packaging machinery. Science and technology innovation and application, 2021.

[2] Qiu Jing. Find the gap to learn advanced innovation to enhance the level of China's future food packaging machinery and packaging technology development. China Packaging, 2008.

[3] Wu Shuang. Design and development of automatic packaging machine for fruits and vegetables. Zhejiang Agriculture and Forestry University, 2014.

[4] Cai Xingshan. PLC zero-based introductory to proficient. Beijing: China Electric Power Publishing House, 2020. 5.

[5] Liu Huafeng, Zhou Junrong, Ye Junlin, Che Haibo, Xu Juan. Application of industrial robots in automatic production line sorting stations. Forging Equipment and Manufacturing Technology, 2020.

[6] Zhang Wei. Packaging machinery design. Beijing: China Light Industry Press, 2020. 6.

[7] Li Jinlian, Li Guang, Wang Dongai. Packaging machinery selection design manual. Beijing: Chemical Industry Publishing House, 2013. 1.

[8] Chen Bing. Electromechanical drive control. Wuhan: Huazhong University of Science and Technology Press, 2022. 1.

[9] Zuo Jianmin. Hydraulic and pneumatic transmission. Beijing: Machinery Industry Press, 2016.

[10] Zhang Yuping. Hydraulic and pneumatic transmission. Wuhan: Huazhong University of Science and Technology Press, 2021