

# Research and Development of Key Technologies for Automatic Bagging Machines in Packaging Production Lines

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## Abstract

In view of the existing carton packing machine covers a large area, expensive equipment and the use of limitations and other issues, the project team designs a carton packaging machine, that has simple structure, and multiple uses and other advantages. The project group uses modular design idea, designs the cardboard feed, carton molding, folding seal and shaping output, and other modules. This paper introduces the composition of the system structure and working principle of different modules. The project group uses CATIA software to complete the three-dimensional structure design of the packaging machine. This paper introduces the hardware composition and control principle of the packaging machine, and designs the moving cam contour curve applied to the carton packer. The motion simulation analysis is carried out by CATIA software, and the correctness of cam profile is verified. The application results show that the packing machine is safe, reliable and flexible. The carton packing machine designed by the research group can be packaged efficiently, safely and quickly.

## Keywords

Carton packaging machine; CATIA software; modular; motion simulation.

## 1. Introduction

In recent years, due to the rapid development of the national economy and the continuous expansion of China's foreign trade, so demand for product packaging is more and more high. All of these urgently require the packaging industry to realize mechanization and automation, thus greatly promoting the development of the packaging machinery industry, so that it occupies a more and more important position in the national economy. With the rise of the Internet consumption model, more and more goods need to be transported for a long time and a long distance. Therefore, the packaging of the goods should comply with the requirements of high efficiency, convenience, environmental protection and low cost. Because of its light material, high strength, good adaptability and green environmental protection, carton packaging is widely used in commodity packaging. Driven by the development of high and new technology, the overall level of automation in the western developed countries is constantly improving, and the packaging technology is ahead of china. So far, the packaging industry in foreign countries has formed a complete industrial system, becoming an important branch of mechanical manufacturing. However, most of the carton packaging machine, can only satisfy one single task, such as carton feeding, carton tape sealing, or automatic packaging of carton by pipelining. This leads to high cost of production equipment and limitations of the use of equipment. The automatic carton packing machine designed by the research group realizes the automatic packaging of the paperboard from feeding to shaping output through repetitive operation of cartons between some stations.

## 2. Structure Design of Automatic Carton Packing Machine

According to the function of automatic carton packaging machine, the research group divides it into 4 modules: cardboard feed, carton molding, folding seal and shaping output. According to the 4 function modules are designed a vertical feed mechanism, vacuum suction board carton forming mechanism, folding mechanism, tape sealing mechanism and box output mechanism. The automatic carton packaging machine is divided in the space into A (cardboard waiting station), B (central station), C (lower hinge folding station), D (upper hinge folding station) and E (boxes output station), station distribution plane as shown in figure 1. Through the mechanical movement of each structure in different working stations, the automatic packaging of the carton is realized.

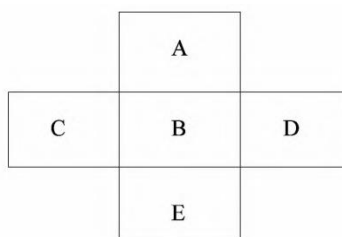
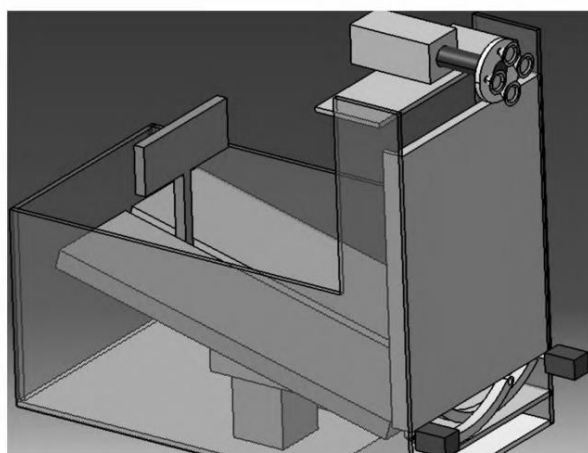


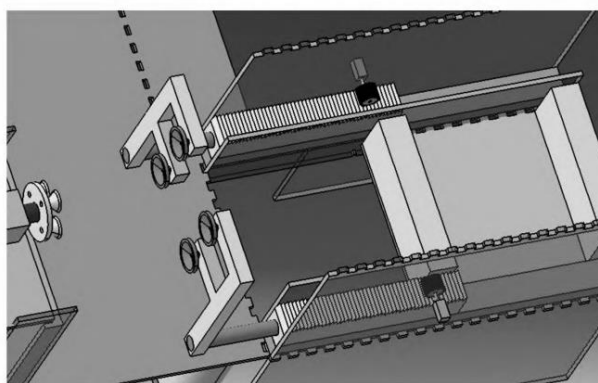
Figure 1 Station distribution plane

The research group applies CATIA software to the 3D design of the 4 modules of cardboard feeding, carton forming, hinge folding and shaping output of the automatic packaging machine. The cardboard feed module moves the cardboard continuously and rapidly from the storage area to the entrance area of the carton forming module, which is mainly composed of a cardboard storage and transportation channel, a vertical feeding mechanism of the paperboard and a vacuum sucker mechanism, etc., which is located at the work station A. The carton forming module expands the cardboard moved to the specified location into a carton and fixed it, which is mainly composed of a vacuum suction cup, a carton forming mechanism and a baffle plate, which is positioned at the work station E. In the vacuum suction disc carton forming mechanism, the rack is connected with the linear motor, the motor drives the gear to rotate, and the rack and the linear motor are pushed out to the position B, so that the linear motor arrives at the work location. When the paperboard has been fixed to the corresponding area, the linear motor starts at the working location, and the sliding rod connecting the truss is pushed out to the station B, so that the fixed vacuum suction plate on the truss is absorbed with the paperboard. Then, the linear motor reverses and drives the slider to move backwards. Using vacuum suction plate stretching and the cardboard fixed the other side, the equipment completes the action of opening box and plays the role of fixing the carton, so as to facilitate the follow-up folding of the carton. When the folding is starting, the vacuum suction plate is released, and the motor is reversed to place the rack and the linear motor in the initial position, so as to prepare for the next opening box of carton. The schematic diagram of the cardboard feed module and the carton forming module is shown in figure 2.

Folding sealing module as the core part of the automatic carton packaging machine mainly realizes the folding carton hinge, sealing tape and automatic loading of goods and other functions. It is located in B, C and D stations, mainly composed of the upper mobile mechanism, the lower folding mechanism, the lower belt sealing mechanism, the goods introduction mechanism, the carton translation mechanism, the upper folding mechanism, the upper belt sealing mechanism, the baffle plate and the bottom plate. The 3D modeling of the folding seal module is shown in figure 3.



(a) Cardboard feed module



(b) Carton forming module

Figure 2 Carton feed module and Carton forming module

After the carton is formed, the 2 electromagnetic relays in the moving mechanism are moved to the station B under the drive of the belt conveyor. When the electromagnetic relay reaches the upper part of the formed carton, it is electrified to make magnetic clamping carton. In the lower folding mechanism, when the conveyor belt moves to the station C, the short side folding of the bottom side of the carton meets with the folding baffle of the short side, so as to shorten the folding of the short side. At this time, the motor is moving to move the cam forward, and the slider moves upward, so that the short side of the carton is contacted with the iron sheet and folded. At this time, the motor rotates forward to drive the moving cam forward, and the sliding rod moves upward, so that the short side of the other side of the carton is contacted with the iron sheet and folded. The motor rotates forward to drive the pushing block connected with the rack, so that the folding on both sides of the carton is folded. The motor is rotating to drive the belt fixing frame and the adhesive tape to move, and the adhesive tape is stuck to the lower part of the carton. After the motor is turned backward, the serrated blade fixed on the sliding rod moves upwards, and the adhesive tape is cut off to realize the lower part of the sealing carton.

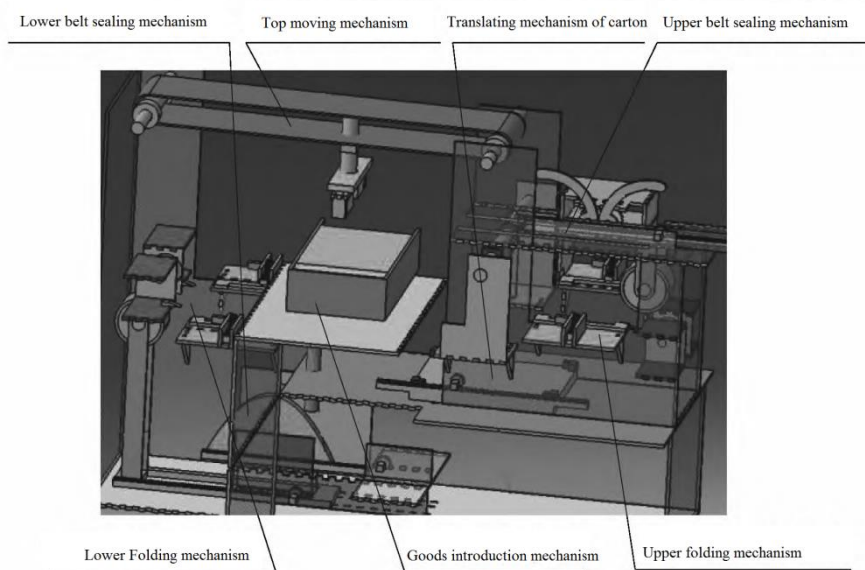


Figure 3 Carton page folding seal

The boxes output is the last link of carton packaging, mainly realizes the finished carton to output packaging machine. The module is located in E station, composed into output mechanism, a bottom plate and a side plate, a three-dimensional model is shown in Figure 4.

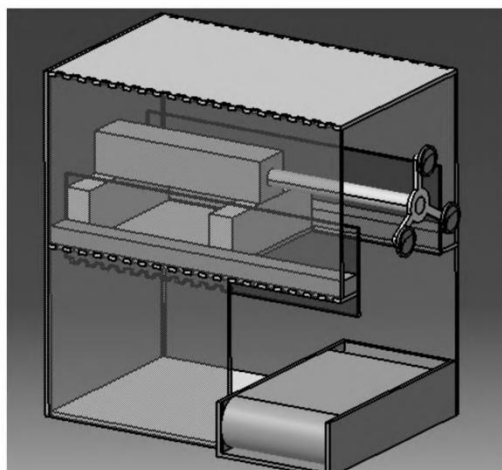


Figure 4 Schematic diagram of mold output

When the carton is finished packing and arrived at the station B, the linear motor in output mechanism starts, and the sliding rod is pushed out, then the vacuum suction cup is contacted with the carton. After the suction cup is adsorbed on the carton, the linear motor reverses and pulls the slider back. When the vacuum chuck is adsorbed, the carton moves from station B to station E. At this time, the vacuum sucker pressure relief, so that the carton fell into the lower conveyor belt, and output packaging machine with the conveyor belt. After the carton output is finished, the mechanism is reset. After the 4 modules and other parts of the three-dimensional structure are designed, CATIA software is used to assemble parts and components. After assembling, the three-dimensional structure of the automatic carton packer is obtained, as shown in figure 5.

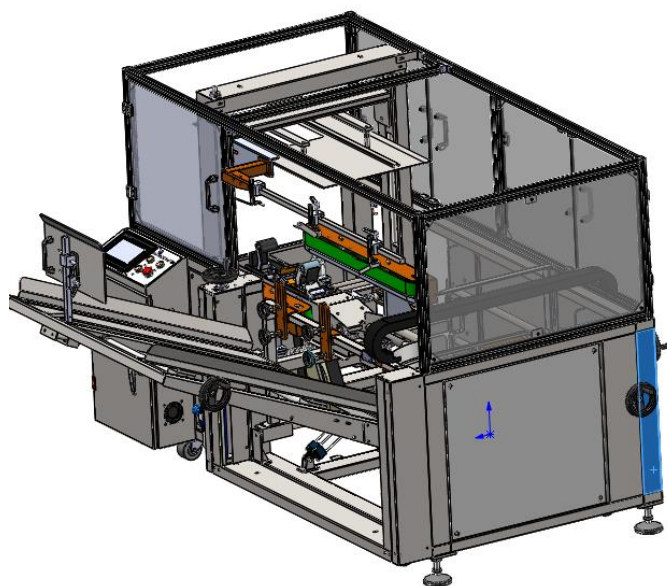


Figure 5 Three-dimensional graph of automatic carton packaging machine

### 3. Automatic carton packaging machine control system

The realization of the motion function of each mechanism of the automatic carton packer depends on the efficient and stable electronic motion control of the machine. Because of the complex motions of carton packing machine, many interference signals, packaging product varieties and specifications, the project group adopts the programmable controller (PLC) which has the advantages of reliable work, strong anti-interference ability, easy connection with the industrial field signal, direct input and output connection, simple programming, convenient installation and maintenance. In order to complete the cardboard feed, carton molding and other modules of the action, the electronic motion control system of full automatic carton packaging machine is mainly composed of PLC, magnetic switch, photoelectric switch, electromagnetic relay, motor servo driver module, servo controller, servo motor, servo motor, gear motor and linear motor and its control principle.

In addition to the PLC electronic motion control system, the control system of automatic packaging machine also needs man-machine interface and packaging machine running position detection device, etc. The man-machine interface is designed with Visual Basic software. The interface mainly includes the start-up and pause of the control packaging machine, the choice of the number and speed of packaging, etc. The running position detection of packaging machine generates feedback signal based on servo motor rotary encoder, servo motor is controlled by servo controller to open-close loop. The position detection is to transfer the data from the main encoder to the motion controller of the automatic high speed carton packaging machine control system. Through the data in the motion controller, the packaging operation position of the carton packer is reflected, so as to carry out the packaging settings and monitor. The packaging machine control system consists of PLC electronic motion control part, man-machine friendly interface and packaging machine running position detection device, etc., which can ensure the safe and stable operation of the machine.

### 4. Conclusion

The research group uses CATIA software to design the three-dimensional structure of carton packaging machine, introduces the hardware composition and control principle of the control system of the packaging machine, and designs the moving cam contour by using MATLAB software. The carton packaging machine designed by the research group is smaller than the

existing packaging machine, and the modular design is more convenient for the maintenance of the packaging machine. After the carton packaging test, there are still problems: (1) changing carton specifications, the packaging effect is not ideal; (2) in the case of continuous operation of the packaging machine, the phenomenon of sticking is easy to occur. The following research of carton packing machine can be combined with mechanical analysis to find out the parts which are easy to be damaged during the operation of the packing machine and improve it.

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