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Design and Test of Box Suction and Opening Mechanism of the Medicine Carton Packaging Machine

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Abstract

In allusion to the problem of low efficiency of medicine carton packaging machine and poor box opening effect of the narrow and long carton, a new box suction and opening mechanism of carton packaging machine with box suction mechanical arm, carton opening auxiliary setting device was put forward. The working principle of the mechanism was analyzed; the kinematics model was built, and compiled the mechanism calculation software to obtain a set of mechanism parameters that can achieve the work requirements. The virtual prototype was built, the kinematics simulation test was carried out to obtain the motion trajectory, and the simulation analysis was basically consistent with the theoretical calculation result, the box suction and opening test of the physical prototype was carried out, and the results verified the correctness of the design results.

Keywords

Medicine Packaging Machine; Carton Box Suction Mechanism; Carton Box Opening Mechanism; Design.

1. Introduction

Due to medical insurance reform, aging and the national concern for health, China has become one of the fastest growing regions in drug consumption in the world. The packaging machine can effectively improve the production efficiency, can greatly shorten the product production cycle, reduce the manual participation in the product production process, and significantly reduce the labor intensity of the workers. At present, the domestic automatic packaging machine still has a certain gap in technology in comparison with foreign countries, and it is only in the middle and high speed stage from operating speed. Foreign packaging equipment has the advantages of high automation, high production efficiency, multiple functions, low energy consumption, high reliability and stability, but the corresponding equipment prices remain stubbornly high, and once encounter problems, the relatively lagging after-sales service and technical support are also unacceptable to many domestic pharmaceutical enterprises. The medicine packaging machine automatically loads the medicine board and instructions into the folding carton, and completes the box cover action. The box suction and opening mechanism is an important part of the packaging machine, it needs to complete the three actions: suction box, open box, put box, and expand the folding carton and send it to the next station. The medicine packaging machine has very strict requirements on the opening effect of the instructions or the carton, the size deviation of the folding instructions is greater than 0.5mm, or the medicine box is not opened in place, and the jam or the medicine box will fail to open. At present, the packaging efficiency of the medicine packaging machine is limited by the box-taking mechanism, and the efficiency is low, which puts great requirement for the rationality of the design. In allusion to this problem, this paper proposes a new box and suction opening mechanism of carton packaging machine

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with three sets of box suction mechanical arms and carton opening auxiliary setting device; analyzes and designs the mechanism, determine the best design parameters, and provide references for the design of the box-taking mechanism.

2. Box-Taking Process

2.1 Process analysis of box-taking action

When the medicine board and the instructions are transferred, the box suction and opening mechanism is needed to take out and open the folding medicine box for loading the medicine board and instructions. Therefore, the box-taking action of the box suction and opening mechanism is divided into the following three actions: I suction box, II open box, III put box. In order to reduce the space, the three stations are arranged on the same circular line, as shown in Fig.1. Process flow: the rotary vacuum sucker suctions the carton surface from the box-supply frame position and takes it out; after rotate 120° counterclockwise, moves to the opening position, the sucker is fixed to inhale to open the carton, at this time, the auxiliary setting device for opening the carton will keep the carton open; when the sucker continues to rotate 120° to reach directly below, the sucker ventilates to the outside world, releases the carton, and the carton falls on the conveyor chain.

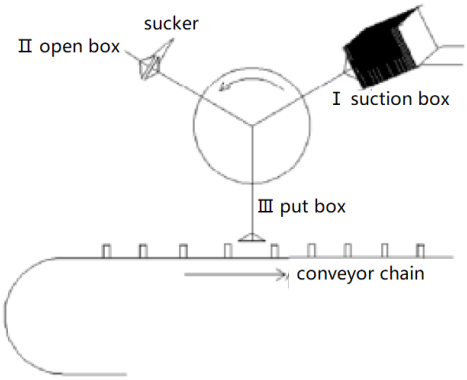

Fig. 1 Flow chart of taking box

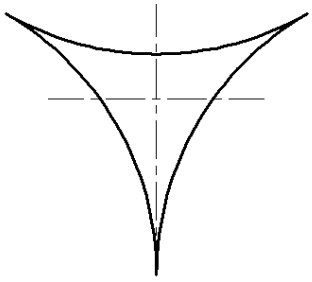

Fig. 2 Triangular hypocycloid trajectory

2.2 Trajectory of taking box

When suctioning box, after the sucker touches the carton surface, there will be a squeezing process to ensure that the sucker can suction the carton stably. According to the requirements of the box-taking process, after the sucker suction the carton, it should be pulled down to get rid of the restraint of the box-supply frame, at this time, the sucker is required to form the trajectory that avoids the box-supply frame when pulling the box, so that the box suction mechanical arm does not interfere with the box-supply frame, in addition, the movement trajectory of the automatic box suction and opening mechanism of the high-speed packaging machine must be continuous, and the three stations are located on the same circumference. The trajectories that meet the requirements include equilateral

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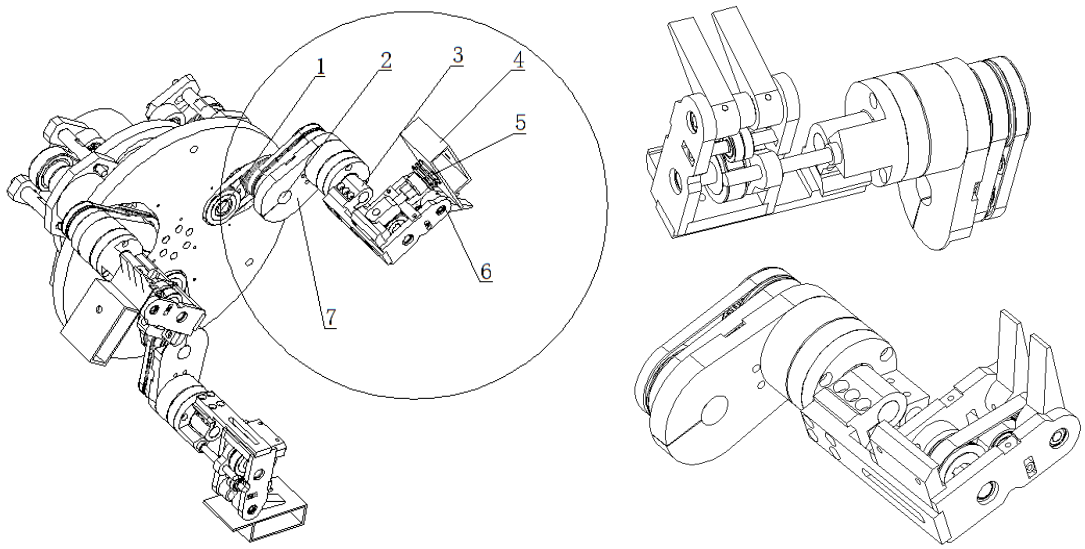
triangle trajectory and triangular hypocycloid trajectory. 60° of the equilateral triangle trajectory cannot be adjusted, which affects the box suction time, and the triangular hypocycloid trajectory (as shown in Fig.2) is a downward pulling force at the cusp of the trajectory during the process of taking box, it cannot be restricted by the box-supply frame, in addition, the entire mechanism is compactly arranged, especially the angle of the front and rear of the suction box can be adjusted at will, so that the key parameters that affect the quality of taking box can be determined, in order to meet the requirements of the suction box trajectory under different conditions.

3. Working Principles of the Box Suction and Opening Mechanism

The working principles of the box and suction opening mechanism are shown in Fig.3. The rotary disc is divided into three equal parts, and each is set with the first rotary shaft 1, the first rotary shaft is correspondingly configured with the second rotary shaft, the second rotary shaft 2 is movably connected with the rocker arm 3, the third shaft 3 is installed on the rocker arm, the second shaft and the third shaft are set with sockets, respectively, the synchronizing wheel on the second rotary shaft can revolve around the large synchronizing wheel while rotating, the synchronizing wheel on the second socket can revolve around the synchronizing wheel on the second shaft while rotating, the synchronizing wheel on the third shaft can revolve around the synchronizing wheel on the second socket while rotating, the mounting frame on the third rotary shaft is set with the sucker 5 and the swing rod 6 (namely the carton opening auxiliary setting device). This mechanism can suction the flat carton 4 placed in the storage box frame, after rotating, it will be suctioned by another suction nozzle to open the box, finally, by swinging the swing rod, the packing box will be squared after opening, and falls onto the conveyor belt, it is easy for pushing items into and packed, and has the characteristics of scientific structure and stable work.



1 The first rotary shaft; 2 the second rotary shaft; 3 the third rotary shaft; 4 paper box 5 sucker; 6 swing rod (carton opening auxiliary setting device); 7 rocker arm

Fig. 3 Schematic diagram of the box suction and opening mechanism

4. Mechanism Kinematics Modeling

The center point of the vacuum sucker revolves and rotates simultaneously during the movement, the box suction and opening mechanism is simplified to the series 3R mechanism, as shown in Fig.4, the coordinate system XOY is built, he first axis O as the coordinate system origin, horizontal is the X axis, and the vertical is the Y axis. The distance from the second axis to the rotation center of the first axis is l_1, the distance from the third axis to the second axis is l_2, and the distance from the center of

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the sucker to the rotation center of the third axis is l_3, the second transformation matrix of adjacent rod coordinate systems of this mechanism is as follows::

$$T_{03}=\begin{cases}\cos\theta_{123} & -\sin\theta_{123} & 0 & l_1\cos\theta_1+l_2\cos\theta_{12}+l_3\cos\theta_{123}\\ \sin\theta_{123} & \cos\theta_{123} & 0 & l_1\sin\theta_1+l_2\sin\theta_{12}+l_3\sin\theta_{123}\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 0\end{cases} \quad (1)$$

In the formula, θ_{ij} is the abbreviation of $\theta_i+\theta_j$. According to formula (1), the center position of the vacuum sucker is:

$$\begin{cases}x=l_1\cos\theta_1+l_2\cos\theta_{12}+l_3\cos\theta_{123}\\ y=l_1\sin\theta_1+l_2\sin\theta_{12}+l_3\sin\theta_{123}\\ \phi=\theta_{123}\end{cases} \quad (2)$$

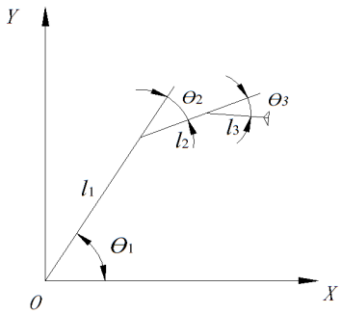


Fig. 4 Creation of coordinate system.

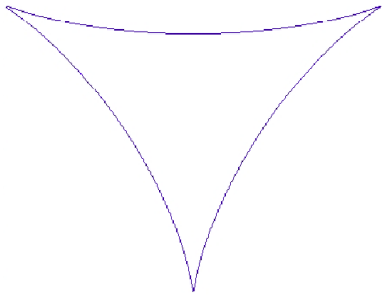
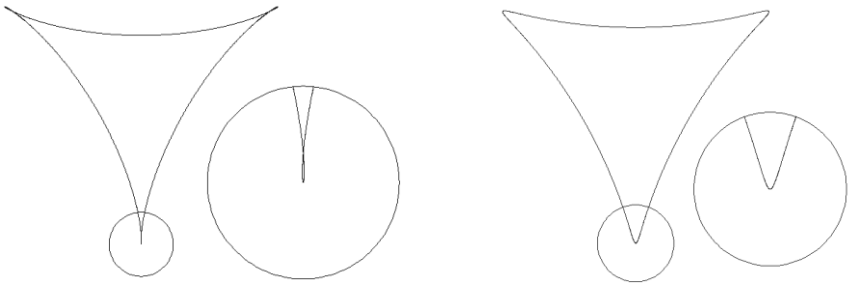


Fig. 5 Theoretical calculation trajectory

According to the requirements of the box-taking process, when the box suction and opening mechanism conduct box suction action, the whole vacuum sucker is on the same straight line with the center of the first axis, the center of the second axis, the center of the third axis, and the center of the sun gear (at 30° to the horizontal line), whenθ_1 is equal to 30°, the three rods are collinear. It can be known from analysis that when θ_2=-3θ_1, θ_3=-θ_2, the triangular hypocycloid trajectory can be realized. But when l_1, l_2, and l_3 take different values, it will affect the shape of the trajectory cusp, thereby affecting the box suction effect. If the trajectory cusp is relatively smooth, the vacuum suction cup reaches the position of the suction box, the sucker is not in close contact with the surface of the medicine box, and missed suction is likely to occur. If there is an obvious crossing phenomenon at the trajectory cusp, when the vacuum sucker reaches the position of the suction box, the surface contact force between the sucker and the medicine box is too strong, resulting in large extrusion deformation, it is easy to cause the vacuum sucker to slip on the surface of the medicine box and box drop phenomenon appear. Therefore, it is necessary to study the influence of rod length on the trajectory, namely the influence of the distance among different axes on the trajectory, and select a set of better solutions.



(a) trajectory when k=0.5 (b) trajectory when k=0.7

Fig. 6 Working trajectory of the sucker when k takes different values

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The relevant parameters of the box suction and opening mechanism provided by the enterprises as the initial parameters, l_1=125mm, l_2=85mm, l_3=60mm, the rod length is optimized based on Matlab software, according to the structure, l_1 remains unchanged, mainly optimize l_2, l_3 rod length, it can be found that from analysis that the greater the ratio of k=l_3/l_2, the more round the trajectory cusp, k=l_3/l_2<0.6, crossing will appear, as shown in Fig.6. By combining the structural design, finally determine that l_1=125mm, l_2=90mm, l_3=55mm, at this time, there is no crossing or roundness at the trajectory cusp, as shown in Fig.5, which meets the requirements for the trajectory cusp.

5. Mechanism Motion Simulation Test and Physical Prototype Test

According to the theoretically calculated size, the structure design of the mechanism is carried out to complete the 3D modeling and assembly. Adams software is used to carry out virtual simulation of the box suction and opening mechanism, set the motor speed of the first axis to 120°/s, the simulation time is set to 3s, and the step length is 200 steps. The virtual motion simulation of the box and suction opening mechanism obtains the static trajectory of the vacuum sucker center of the box-taking arm, and compares it with the theoretical and calculated trajectory, the trajectory in Fig.5 is the theoretically calculated working trajectory, and Fig.7 is the simulated working trajectory, it can be seen from the figure that the trajectory obtained by virtual simulation analysis is basically consistent with theoretically calculated trajectory, therefore, preliminarily determine the design correctness of the box suction and opening mechanism of the carton packaging machine. In order to further verify the rationality and correctness of the design, the kinematics test and the box suction and opening test of the physical prototype are carried out, the comparison error between the suction box position and the virtual simulation position is 0.5%, the attitude error is 0.8%, and the speed of principal axis is 360r/ min, carry out the box suction test, the success rate of box suction of 1000 carton reaches 99.5%, and the success rate of box opening reaches 99.8%. The results show that the design meets the requirements.

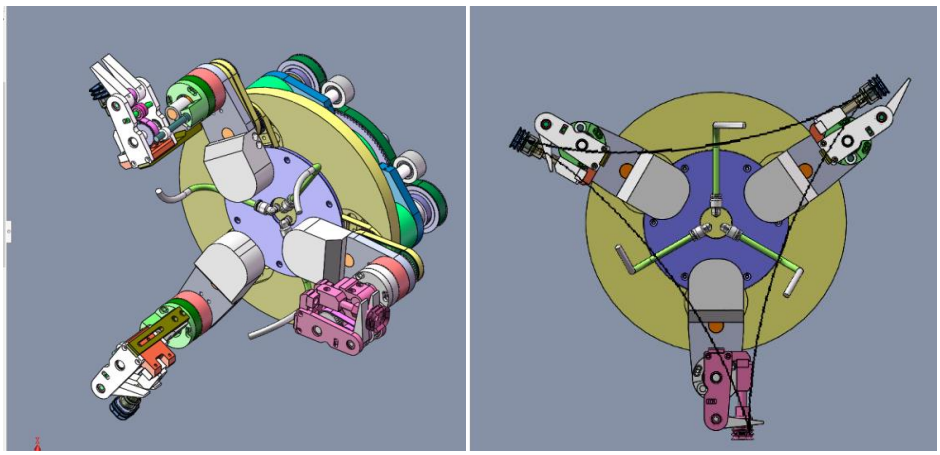

Fig. 7 Virtual simulation test and trajectory

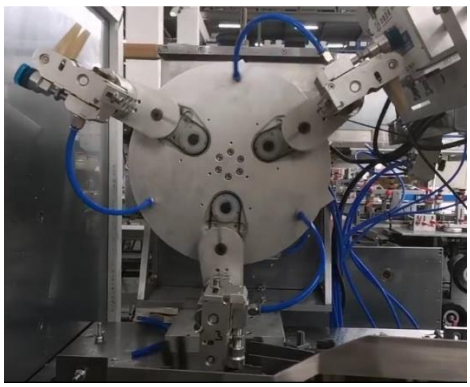

Fig. 8 Physical prototype test

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6. Conclusion

(1) The mechanism characteristics of the existing box-taking mechanism were analyzed, a new box suction and opening mechanism of carton packaging machine composed of three sets of box-taking arms was proposed and an auxiliary setting device was added. The box suction and taking mechanism has a better working trajectory, moreover, it can have the function of assisting in setting after opening the box, improves the box opening effect, increases the success rate of box packing, and thereby improves the carton packaging efficiency.

(2) The simulation trajectory of the sucker center of the box suction and box taking mechanism is basically consistent with the working trajectory obtained by theoretical calculation via the virtual prototype simulation of the box suction and opening mechanism and the motion test of the physical prototype, the position and attitude errors of the actual prototype test and the simulation test are 0.5% and 0.8%, respectively, the success rate of box suction is 99.5%, and the success rate of box opening is 99.8%, the design correctness of box suction and opening mechanism of carton packaging machine was verified, and it shows that this mechanism has the feasibility of being applied in actual machines.

Acknowledgments

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