Kinematics and Dynamics Simulation Analysis and Designing of Anchoring Agent Package-buckling Mechanism Based on Virtual Prototype Technology

Lijun Shan[1], Jingfu Li[2]
[1]*School of Mechanical engineering, Dalian Jiaotong University, Liaoning Dalian, China, 116028*
Email: s2002lj@yahoo.com

Abstract: It is introduced about anchoring agent packaging buckling mechanism drive system and its operating principle in the paper. The virtual prototype of anchoring agent packaging buckling mechanism is built by Pro/E software and ADAMS software. Simulated dynamics analysis is carried out. It is gotten that the motion curves of the buckling mechanism lift platform such as the displacement, velocity and acceleration. It is learned about the characteristics of its relative motion of the buckling mechanism. By comparing to simulated data with the theory value, it is analyzed that the motion of the buckling mechanism affected by the velocity of the lift platform which meeting with the condition of the buckling, and proving that the virtual prototype model is stable.

Keywords: buckling mechanism; virtual prototype; PRO/E；ADAMS;

1 Introduce

The buckling mechanism plays an important role in anchoring packaging. The velocity of alternating motion of buckling mechanism and film moving should keep consistent. Keep the package of anchoring agent away from the phenomenon of pulling and squeezing broken. If the film moving is too quick, it may be squeezed broken where the knife squeezes the aluminium wire. If the film moving is too slow, there is much difference of velocity between the buckling lift table and film moving. Thus the film will be pulled broken. The buckling mechanism is composed of oval gear and sine mechanism. The quality of buckling lies on the characteristic of the movement of the buckling mechanism. The movement of the buckling mechanism should keep stable, and it is sure that there is the quick returning motion when it is not in working time. So there is a higher request in transmission accuracy and dynamics characteristic. Traditionally, a kinetic analysis of a new product needs to be designed and made a physics prototype. But the developing cost considerably higher, and the period is considerably longer. As the virtual prototype technology is gradually mature and is extensively applied, by analyzing and simulating in the kinematics and kinetic of virtual prototype, it is able to check the product function in initial product designing stage. So it will reduce the product designing defect and raise a level of a product. It analyzed the dynamics characteristic of the buckling mechanism system by building the virtual prototype of the buckling mechanism system.

2 The operating principle of the buckling mechanism

2.1 The drive system of the buckling mechanism

The drive system of the buckling mechanism is as shown in Fig. 1. While it is working, the motor transmits the drive force to the strap wheel 7. The gear Z1 is driven by shaftⅠ. The gear Z1 and gear Z2 are meshed each other. The gear Z2 and gear Z3 are in the same shaftⅡ. The gear Z3 and gear Z4 are meshed each other. The gear Z4 and the cam 1 is an integral whole, it drives shaftⅢ. At the same time, the cam 1 drives the lift table to move up and down by staff 4. And the shaft Ⅲ and shaft Ⅳ are driven by a couple of oval gears Z5、Z6. The bevel gear Z7 and Z8 are meshed, the drive transmits to the part of buckling which is composed of sine mechanism. All above compose the buckling mechanism drive system. All levels drive ratio as follows:

The column gear drive ratio:

$$i_{gear} = \frac{Z_2 \times Z_4}{Z_1 \times Z_3} \tag{1}$$

Where, Z1=22, Z2=80, Z3=26, Z4=130.

The oval gear drive ratio:

$$i_{oval} = \frac{1 + 2e\cos\phi + e^2}{1 - e^2} \qquad (2)$$

Where, e —oval gear eccentric throw, ϕ —oval gear polar angle;

The bevel gear drive ratio:

$$i_{conic} = \frac{Z_7}{Z_8} \qquad (3)$$

Where, $Z_7 = Z_8 = 24$

Multiply, (1),(2),(3) formula, get:

The buckling mechanism total drive proportion:

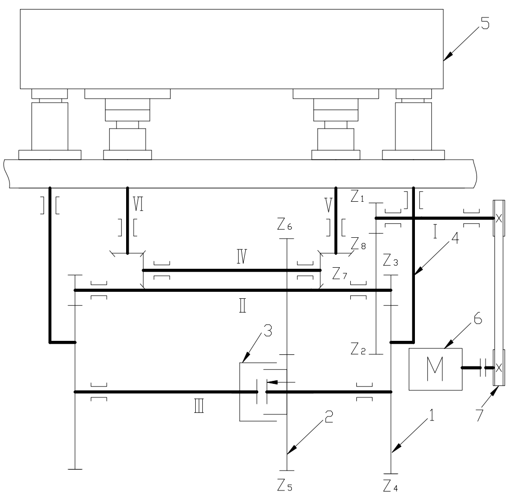
$$i_{total} = i_{gear} \times i_{oval} \times i_{coinc}$$

$$= \frac{Z_2 \times Z_4}{Z_1 \times Z_3} \times \frac{1 + 2e\cos\phi + e^2}{1 - e^2} \times \frac{Z_7}{Z_8} \qquad (4)$$

Known, $e \approx 0.383$, The buckling mechanism overall drive ratio:

$$i_{total} = \frac{20.85 + 1055\cos(\omega_1 t)}{0.8533} \qquad (5)$$

Where, ω_1 —driving oval gear angle velocity.



1-cam 2- a couple of oval gear 3-clutch 4-staff 5- lift table 6-motor 7-strapwheel

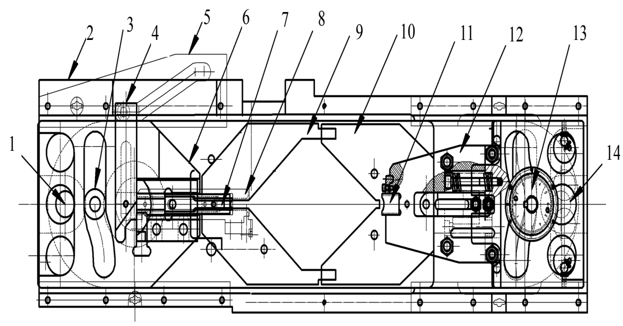
Fig.1. The drive diagram of the buckling mechanism system

From formula (5) known, the buckling mechanism drive ratio is cosine function about driving oval gear angle velocity. The motion velocity of buckling shows periodic change.

2.2 The operating principle of the buckling mechanism

The structure of the buckling mechanism is as shown in Fig. 2. Its operating principle: The drive is imported by shaft Ⅴ and shaft Ⅵ in Fig. 1. It drives crank shaft 3 and 13 to running. The two cranks impel the buckling slider 6, 12 to move left and right to and fro. As the same time, the both sides shutting plates 9, 10 also keep moving with it. It is sure that the motion of buckle and the buckling place keep so synchronous that it can't affect product moving downward continuously. When it moves to the entering wires position, the knife 8 will cut off the aluminium wires. The buckling "U" mould swings upward and makes the two pieces of the aluminium wires be "U" buckle.

The aluminium wires will be mould in advance, so that the aluminium buckles aim at the place of the product section. When the buckling lift table 2 moves downwards to the lowest place, the buckling forming mould returns to the beginning of the place. The left and right clasing plates 9, 10 close. At the same time, the buckling chopping plate 11 will move toward the buckle, and the buckle will be squeezed as a ring buckle. The ring buckle clasps the place of the product section firmly, the blank place of the firm is apiece clasped a ring buckle up and down. Thus the buckling mechanism fulfills a working circle.



1-left staff 2- lift table 3-left crank shaft 4-wire knife pushing plate 5-guiding plate 6-left slider block 7-mould knife head 8-pushing plate 9-left clasing plate 10-right clasing plate 11-chopping plate 12-right slider block 13-right crank shaft 14-right staff

Fig.2.The structure drawing of the buckling mechanism

By using the lifting cam, the buckling lift table 2 is lift up and down by the left staff 1 and right staff 14. When it moves to the lowest place, the velocity of the lift and the firm will keep identical. So there won't produce interference between the clasing plates and the buckling intercourse platform up and down [1].

3 The design of the virtual prototype of the buckling mechanism

3.1 The building of the virtual prototype

The dynamics analysis model [2] of anchoring agent packaging buckling mechanism is built by using Pro/E software and ADAMS software. Mech/Pro is an interface to connect with seamless Pro/E and ADAMS. It's sure that the data has no loss in the course of transmitting. Thus the data of the model achieves accurate transmission [3].

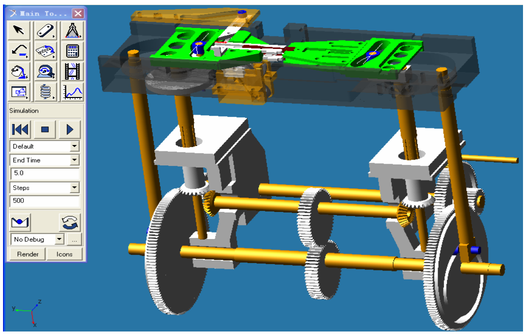


Fig. 3. The virtual prototype of the buckling mechanism

Table 1. The constrains and loads of the buckling mechanism

constrain object	constrain name	load name	value
shaft and groud	revolute	mass of lift	117kg
frame and ground	fixed	cutting aluminum wire	502N
gear and shaft	fixed	squeezing U-aluminum	118.4N
gears	gear	—	—
bevel gears	gear	—	—
oval gears	contact	—	—
bevel gear and spline shaft	translational	—	—
spline shaft and crank	fixed	—	—
slider block and crank shaft	point curve	—	—
lift table and staff	fixed	—	—
silder and lift	translational	—	—
cam and staff	point curve	—	—

First, the 3D model of the buckling mechanism is built in Pro/E. The basal constrains and loads are imposed on Pro/E by using interface software Mech/Pro, and rigid body is defined, the material attributes are imposed on all parts. The mass of the lift table and the buckling stress are calculated.

The constrains and loads of the buckling mechanism are shown as Table 1, and the model is imposed with the constrains and loads transmitting into ADAMS [4]. The virtual prototype of the buckling mechanism is built eventually. It is shown as Fig. 3.

4 The buckling mechanism dynamics simulation analysis

The buckling mechanism has a certain product capacity range. When it is out of range, the buckle can not be produced or may lead to product quality problems. The dynamics simulation analysis is carried out for observing whether the buckling mechanism meets production requirements in different production range to ensure stability of the organization.

Table 2 The packaging range of buckling mechanism

Production rate P（Packages/min）	15～120
Packing length L（mm）	152～406
Maximum film speed V（mm /min）	20320

The packaging range of the buckling mechanism is shown as table 2, the packaging area of the buckling mechanism meets: L=V/P. The packaging capacity of the mechanism is packages / min, 50 packages / min, 15 packages / min, for example. The maximum film speed is shown as Table 3. When the lifting table reaches the lowest end, observe whether it will squeeze or pull the firm. Try to observe the acceleration and velocity characteristics, to analyze the stability of the buckling mechanism, whether it will have the shock.

Table 3. Maximum film speed

Production rate P (packages/min)	120	50	15
Packing length L (mm)	152～169	152～406	152～406
Maximum film speed V(m /s)	338.7	338.7	101

4.1 The dynamics simulation of the lift table

The lifting table is the carrier of the buckling mechanism. The buckling accuracy is relative to its motion accuracy, stability and its dynamics characteristic. To test whether the transport of the film is interfered by the buckling mechanism, the characteristic of dynamics of the lift table is analyzed. Using the data of the cam lifting, the displacement of the buckling mechanism is calculated and compared to the simulation results. The cam lift distance is 75mm, the cam drive parts in accordance with the laws of motion to amend sine, cam motion law curve is shown as Fig. 4.

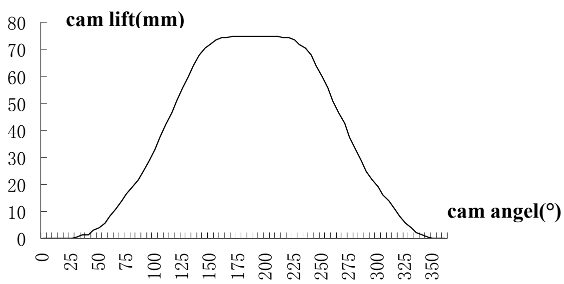
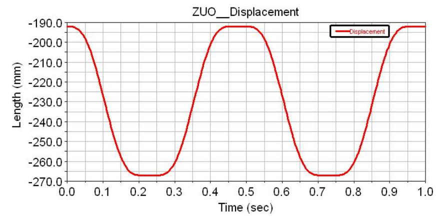


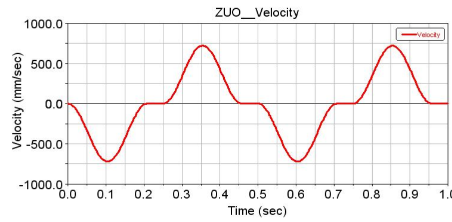
Fig. 4. The cam motion laws curve of lift table

In accordance with packing capacity such as 120 packages / min, 50 packages / min and 15 packages / min, the lifting table is carried the simulation and analysis. It is shown as Fig. 5. By comparing the lift cam displacement curves with the theoretical curve, the variety of the curves is same, the motion law of the lift table meets the theoretical requirements. When the lift reaches the highest position and the lowest position, the cam pushing staff is in the far ending and the near ending. With the production capacity changing, the velocity and acceleration of the buckling mechanism are also continuously changing, but there are differences in peak of curve.

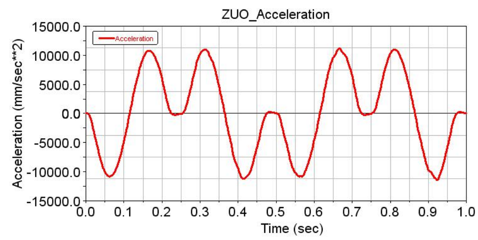
The highest velocities are such as 719.6mm/s, 300 mm/s and 90 mm/s. The highest velocities take place between the far ending and the near ending. When the production capacity is 120 package / min, the returning velocity is 338.7 mm / s, the value is close to the near ending. Obviously, the returning velocities such as 338.7 mm / s, 300 mm / s and 90 mm / s are close to maximum velocity of firm. So the motions of the buckling lift table meet the buckling condition: The mechanism buckles at the lowest position, and the buckling lift speed and film speed are in the coordination; there is no impact on the lift platform motion.



(a) The lift table displacement curve



(b) The lift table velocity curve



(c) The lift table acceleration curve

Fig. 5. The lifting table dynamics characteristic curve when the production capability is 120packages/min

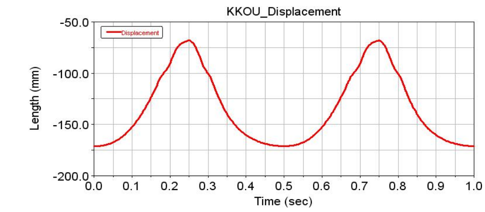
4.2 The Simulation of the buckling

The buckling part is composed of the oval gears and sine mechanism. Try to study the laws of motion and observe whether the mechanism is stable. The three kinds of packing capacity is shown as Fig. 6, the lifting table dynamics characteristic curves. The buckling mechanism do the reciprocating motion, the displacement curve shows a peak and a rough in period. The curve changes slower near the trough, its frequency domain is wider.

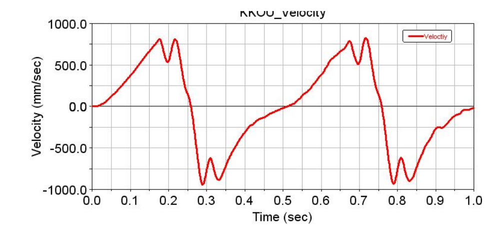
The curve changes fiercely, its frequency domain is narrower. Combining the velocity curve, it’s easy to see that the velocity of slider keeps stable. When it is returning, the velocity is changing quickly. When it moves to the vertical position of the crank, its velocity has a certain buffer. The velocity curve appears at a turning point

978-1-935068-42-6 © 2010 SciRes.

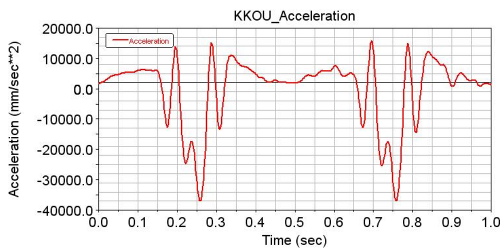
in the peak. The buckling mechanism has a quick returning motion, so that it can improve efficiency. With the product capacity improving, the velocity of the buckling mechanism tends to be stable. With the productivity reducing, the velocity and acceleration remain unchanged, the system is stable.



(a) The buckling displacement curve



(b) The buckling velocity curve



(c) The buckling acceleration curve

Fig. 6. The buckling mechanism dynamics characteristic curve when the production capability is 120packages/min

When it is at the lower product capability, the curve changes stable. As the oval gears model has a little error, the contact has the rebounding phenomenon. When the oval gears speed is relatively higher, the returning speed is lower, the curve is stable; when the speed is lower, the returning speed is higher. Thus the curve occurs to the saw-tooth fluctuation.

5 Conclusion

In this paper, a virtual prototype model is established by combining Adams and Pro / E. The dynamics simulation of the lifting table and the buckling mechanism is carried out to measure the characteristics of the buckling system motion, there are some conclusions as follows:

(1)When the film transmits downwards, by measuring the virtual prototype data, it can be inferred that the buckling lift table speed and film speed are the coordinate basically. The three kinds of velocity such as 338.7 mm / s, 300 mm / s and 90 mm / s are all close to the maximum film velocity. So the condition should be satisfied when the film is buckled: the buckling mechanism buckles in the lowest position of the lift table motion, avoiding the film being pulled and crowed broken. The motion of the lift table meets the amendment sine motion law, there is no impact. The system meets the design requirements;

(2)By using the oval gears and the sine mechanism in combination, it ensures the buckling motion is with the quick return movement, which greatly improves the product packaging efficiency. With production capacity decreasing，velocity and acceleration change a lot, the buckling is no impact; With the production capacity increasing, the curve changes stably， the system is stable, there is no impact, ensures the packing quality. As the oval gears model has a little error, the contact has the rebounding phenomenon. When the oval gears speed is relatively higher, the rebounding speed is lower, the curve is stable; when the speed is lower, rebounding speed is higher. Thus the curve has the saw-tooth fluctuation.

References

[1] Xu Jin Su, Zhao Yun. Kinematics and dynamics simulation analysis of the capsicum mechanism anchoring agent packaging buckling based on ADAMS and ANSYS [J]. Zhejiang University of Technology, 2009, 26 (5) :731-733.

[2] Shao-jun. The analysis of the impact characteristics of the large scale wind turbine gear system based on the virtual prototype [D]. Beijing: North China Electric Power University, 2008.

[3] Liuzhi Bo, Yu Hongyun. Pro / E, ADAMS and ANSYS in virtual design combined with [D]. In Changsha: Central South University, 2008.

[4] Xu Tao, Wang Jianping. Based on Pro / E, ANSYS and ADAMS simulation of the dynamic joint [D] Xi'an: Xi'an Polytechnic University, 2009.