

Structure Design and Analysis of Pineapple Picking Mechanism Based on the Principle of Shutter Mechanism

Wang Qian¹, Wu Huaqiang¹, Zhang Zuling¹, Wei Xiang¹,
Zheng Weigang², Wu Youan³

¹School of Electrical and Mechanical Engineering of Wuhan University of Technology, Wuhan 430063, China

²School of Logistics Engineering of Wuhan University of Technology, Wuhan 430063, China

³Hubei Kefeng Transmission Co., Ltd. Wuhan 430063, China

Introduction of author: Wang Qian(1998—),male gender, bachelor degree in reading,775316545@qq.com

Corresponding author: Zheng Weigang(1967—),male gender, bachelor degree, 416959307@qq.com. Research direction: intelligent robot.

Abstract: At present, pineapples are picked mainly by artificial picking, This picking method is labor-intensive and low picking efficiency. In order to achieve the purpose of picking pineapples of different sizes, a picking mechanism of pineapple picking machinery based on the principle of shutter mechanism is designed. Through the opening and closing of the shutter mechanism to achieve the holding of pineapple, screwing pineapple and picking. Firstly we get SolidWorks' model of virtual institutions. Then ADAMS was used for dynamic analysis and ANSYS was used for static analysis to analyze the rationality of its design, and to use the physical object for verification..

1. Introduction

Pineapple is one of the most distinctive and advantageous tropical fruit varieties in the tropical and subtropical regions. The industry has become an important industry to promote the agricultural economic development in the main producing areas of south China. Since 2005, our country has become the third largest pineapple producing country in the world . In mainland China, pineapples are mainly concentrated in Leizhou Peninsula in Guangdong, eastern and northern part of Hainan Island, and mainly in Guangdong, Hainan, Guangxi, Yunnan, Fujian and Taiwan [1].

The current picking method in China is still traditional artificial picking. The artificial picking is inefficient and labor-intensive. A large amount of labor is required in the short-term operating time of pineapple picking, which makes the labor cost of manual labor accounting for 40% of the total cost [2]; Most of the domestic pineapple mechanization research is staying in the design and experimental stage. There is no mature product. There are existing designs: Based on the identification field Pineapple monocular vision, pineapple adjustably gap picking truck chassis type, an apparatus for automatically picking pineapple, pineapple fruit picking machine for automatic acquisition of the tropical green picking Pineapple Car, pineapple picking machines, etc. [3-5].

At present, the researches in foreign countries tend to use pick robots. The picking robots mainly



consist of four systems, such as manipulator, end effector, visual identification system and walking device. These picking robot can meet the pineapple harvesting in the standardized pineapple planting area, but cannot efficiently pick pineapples of different heights and different sizes, has limitations. Or use large-scale mechanized equipment to assist the manual picking or artificial picking. Figure 1 is a large-scale mechanical equipment.



Figure 1. large mechanized auxiliary picking equipment

Therefore, the research and development of pineapple picking machinery and equipment is great significance for alleviating labor shortage, stabilizing the picking quality, reducing labor intensity, increasing production efficiency and income of pineapple and transporting efficiency. This paper design a pineapple picking mechanism which can provide reference for the key components of the field pineapple picking machine.

2. the design of shutter pineapple picking mechanism

2.1 the composition of shutter pineapple picking mechanism

The picking mechanism mentioned in this paper is inspired by the shutter of the camera and is improved on the basis of the shutter principle and modeled by SolidWorks software. The picking mechanism is mainly composed of six shutter slider, a ratchet, a spur gear, six splints, a pawl, a mechanism support platform; it is shown in Figure 2. The use of DC motor as the main driving force, the mainstream motor rotation, driven spur gear external gear rotation, spur gear external cylindrical gear rotation through the shutter slider on the following shutter slide block movement, and the shutter slider is a total of 6 , The slider is stuck in the hexagonal groove on the ratchet through the boss on the bottom. When the gear rotates, the six shutter sliders move in the groove at the same time, form a closed reduction of the hexagon; if the motor reverses , The gear is reversed and the shutter slider moves in the reverse direction, thus it can drive the hexagon to enlarge and open. The shutter slider is shown in Figure 3, ratchet parts shown in Figure 4.

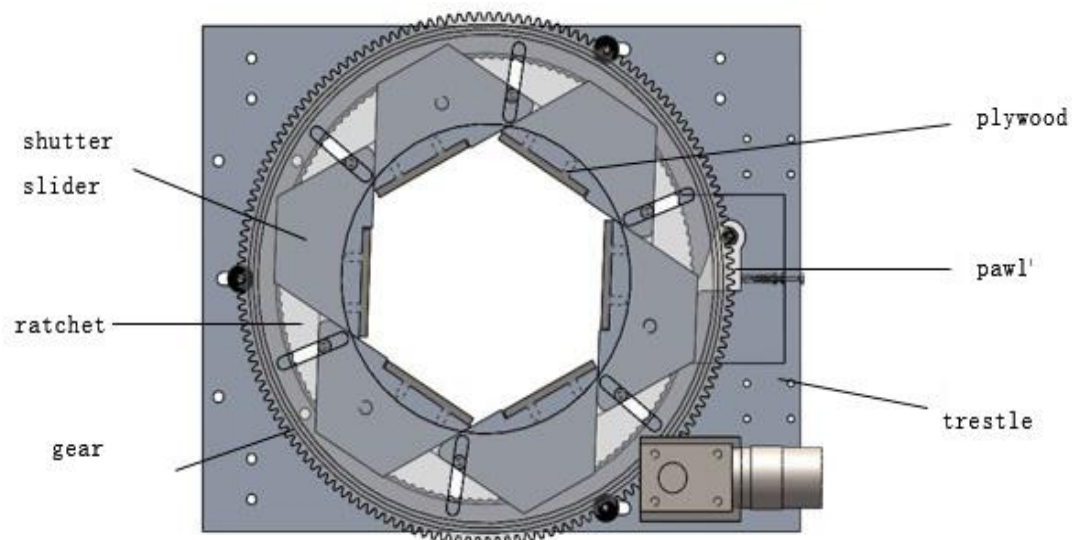


Figure 2. Shutter mechanism diagram

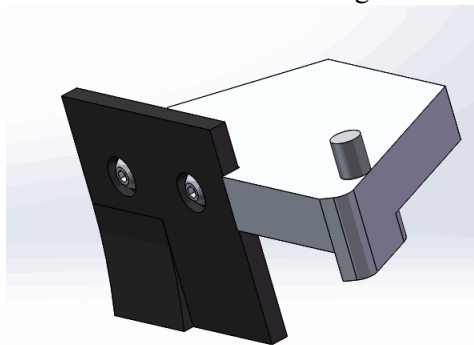


Figure 3. Shutter slider

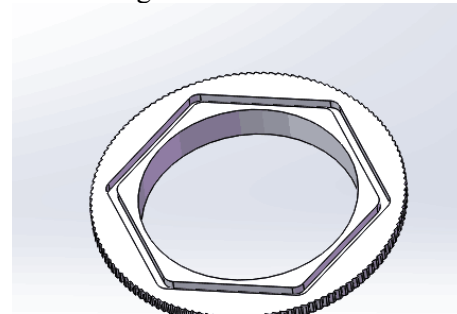


Figure 4. ratchet

2.2 shutter pineapple picking mechanism movement process

Picking module's work is divided into two processes, slider collapsed and reversed in the process of 1, slider clamped pineapple for screwing in the process 2.

2.2.1 Process 1

Process 1 is a process of closing and reversing six sliders; the motor rotates forward when the sliders are closed, and the spur gears rotate due to the friction between the sliders and the ratchet tracks being smaller than the friction between the ratchet and the machine pallet and the pawls, So that the straight-tooth cylindrical external gear rotates 6 shutter slide block in the ratchet orbit, the central hexagonal enclosed shrinking until the clamp fixed pineapple, Figure 5 is a fixed flow diagram; the other hand is the reverse process.

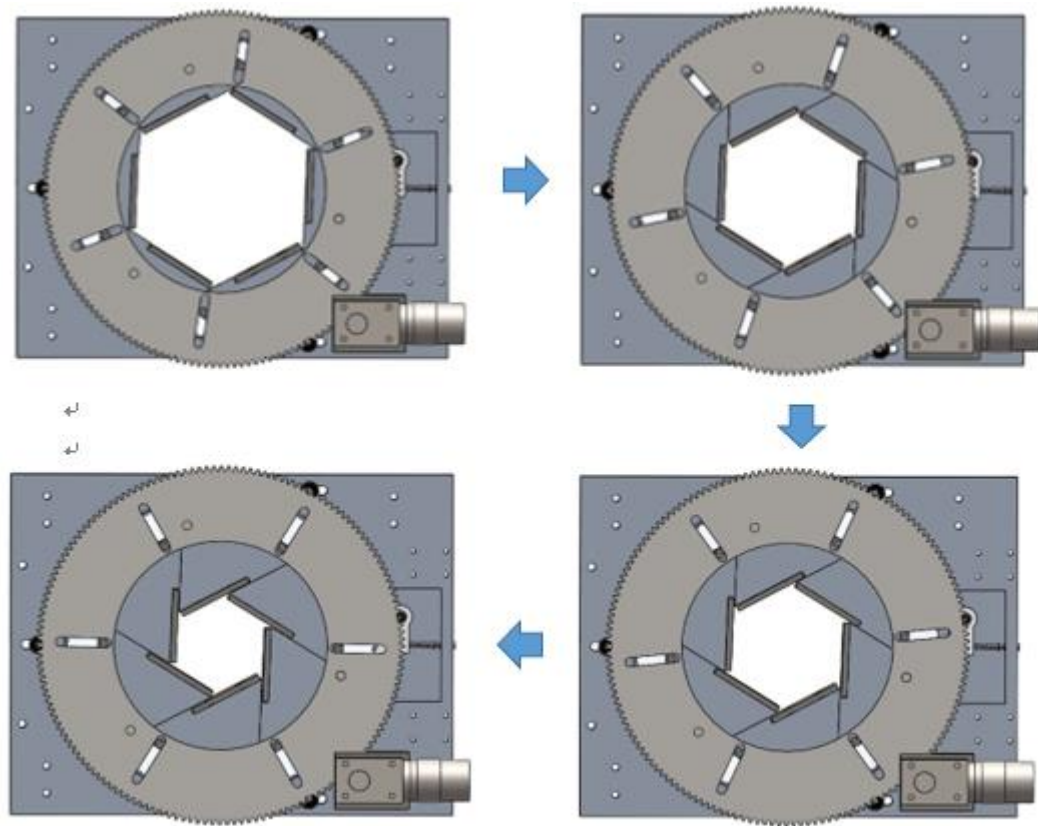


Figure 5. Fixed flow diagram

2.2.2. Process 2

Process 2 is to clamp the pineapple for screwing; when the six sliders are closed to the diameter of the pineapple to fix the pineapple, the straight cylindrical external gear continues to rotate. At this time, the slider has gripped the pineapple and can not be in the ratchet groove. Continue to slide, which led to the following ratchet rotation, by rotating the pineapple from the handle off. Shutter mechanism's organization diagram of two processes is shown in Figure 6.

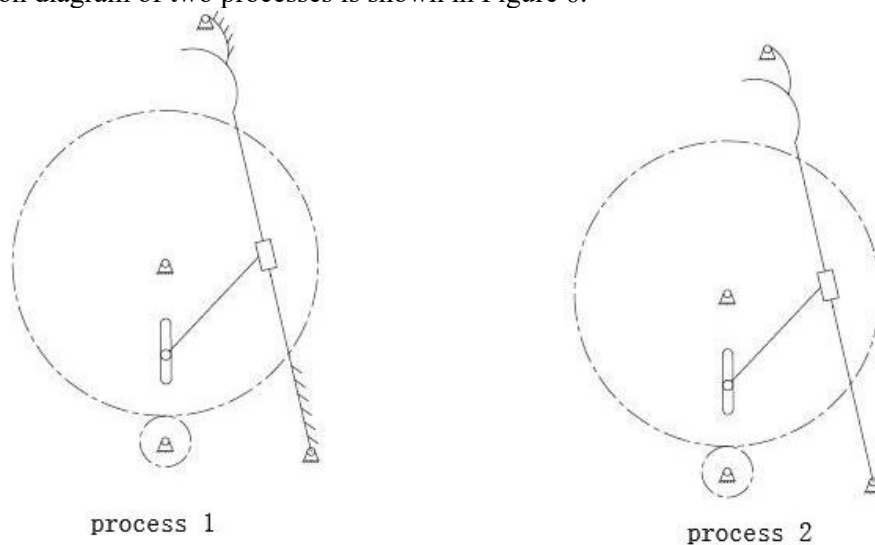


Figure 6. Organization diagram

3. analysis and experiment of pineapple picking mechanism

3.1 dynamic analysis

3.1.1 establishment of virtual prototype model

According to the need of simulation, the large platform, bearing and other fixed components of the shutter mechanism are simplified to the earth model. The simplified shutter mechanism model only includes the upper wheel, the lower wheel and the sliding block. The shutter mechanism model established in Solidworks is exported in parasolid format and imported into ADAMS software.

After importing the model, add quality to its assembly, that is, in the quality property bar, select materials, select steel, define mass by -- geometry and material type -- material type -- guess -- steel. Then, according to the motion of the shutter mechanism, the constraint is added, and the fixed constraint is added between the lower wheel disk and the earth. Between each sliding block and the lower wheel, the moving pair is added, namely the lug is moving along the chute in the chute. Add rotation pair between slider and screw; Add a moving pair between the top wheel and the screw. The model diagram in ADAMS is shown in figure 7.

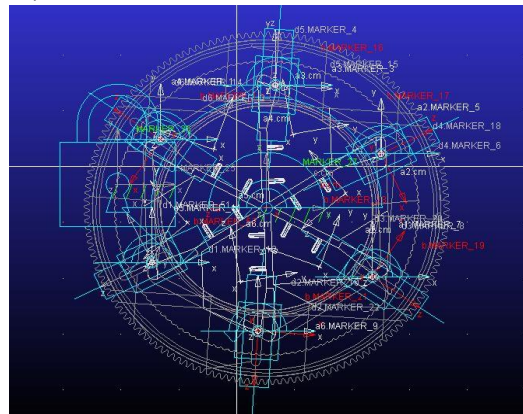


Figure 7. add the constrained model diagram

3.1.2 simulation result analysis

Set the unit of system to MKS (m, kg, s, N), add a rotating to the center of the upper wheel drive, the size of 30 d * time, namely the second 30 ° into simulation for dynamics simulation. After the simulation is finished, enter the PostProcessor post-processing module to see the desired result curve.

In the process of motion, the stability of the slide block plays a decisive role in the operation of the whole mechanism. Therefore, the center of mass of the sliding block is selected to generate the function diagram of the travel trajectory, velocity and acceleration under normal working conditions. According to the function diagram, the change of velocity and acceleration is small, and the operation of the mechanism is stable and reliable. Figure 8 is the stroke diagram of the center of mass. Figure 9 is the velocity function diagram. Figure 10 shows the acceleration function diagram.

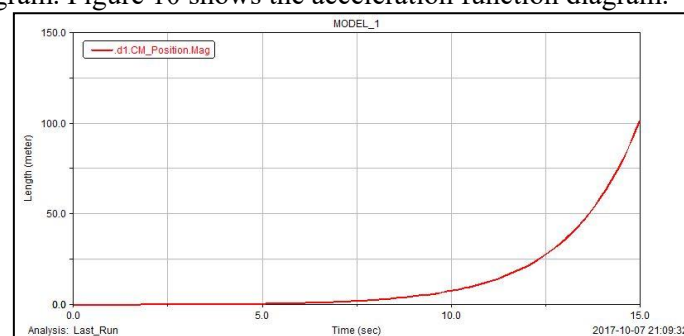


Figure 8. mass flow chart of sliding block

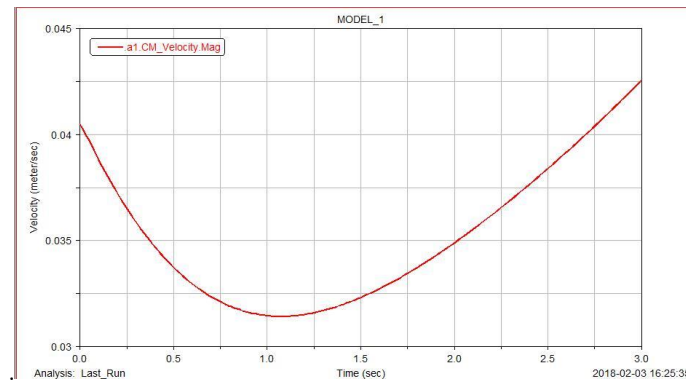


Figure 9. mass center velocity function diagram of sliding block

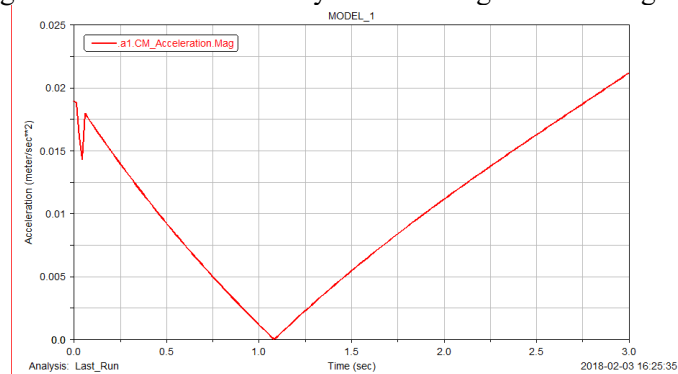


Figure 10. the center of mass acceleration of the slider

3.2 static analysis

In this paper, ANSYS workbench static analysis is carried out on the mechanism of picking module.

After importing the model in the ANSYS workbench software environment, the elastic modulus of the hard aluminum alloy was added as 7.0×10^{11} Pa, the Poisson's ratio of PRXY was 0.3, and the Density was 2.7×10^3 Kg/m³. Reasonable finite element model of constraint condition is the basic requirement of finite element analysis [6], use displacement command to fix the upper plane, the ratchet and six sliders are installed in the recess grooves, and their own gravity is borne by the plane of three grooves. Applying the force command to apply pressure 16.7N on the plane of the three grooves, The gravity of the gear is transmitted by the bearing bolt, which is borne by the plane on the platform of the mechanism, we use pressure command in institutions applying 100 pa compressive stress on the plane. Then, the grid division is carried out, and the load of corresponding parts is applied and solved. The equivalent deformation diagram of the mechanism is shown in figure 11. The equivalent stress cloud diagram is shown in figure 12.

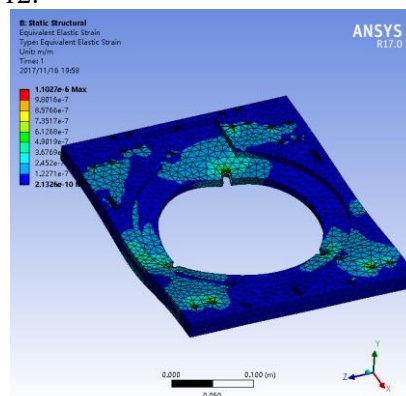


Figure 11. the equivalent deformation diagram of the mechanism support platform

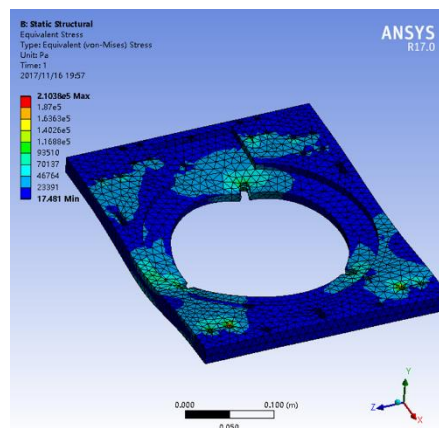


Figure 12. the equivalent stress cloud diagram of the mechanism support platform

By the total deformation diagram of the parts, and the maximum deformation amount of the mechanism support platform under load is 1.1×10^{-6} m, which occurs in the support position of the ratchet groove. Pallets by trying to know parts such as effect, the maximum stress is 0.21 MPa, the stress mainly concentrated in mechanism support platform's several installation support hole position and ratchet support groove, the deformation does not affect the use, meet the demand.

3.3 physical experiment

According to the dynamics and statics analysis above, we use physical mechanism processed by virtual mechanism to work out picking experiments, the experimental figure as shown in figure 13, 14, 15, according to the experimental phenomenon of picking, the mechanism runs smoothly, and the pineapple can be plucking smoothly.

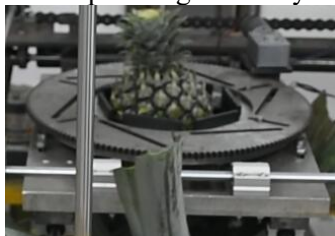


Figure 13. cover pineapple



Figure 14. twist pineapple



Figure 15. take off pineapple

4. Conclusion

Through the modeling, analysis and experimental verification of the pineapple picking mechanism, we get a pineapple picking mechanism based on the shutter mechanism principle. Its rotation during the movement can achieve the different sizes of the pineapple clamping and screwing. The application of the shutter mechanism to the pineapple picking has certain guiding significance for other fruit picking, and extends the train of thought in picking fruit and provides reference for the design of the key part of the pineapple picking mechanized equipment.

References

- [1] Jin Yan. 2015 development report and the situation China pineapple industry forecast [J]. *World tropical agriculture information*, 2016 (09): 16-24.
- [2] Liao Jinwei, Zhu Yuqing, Luo Kuo, Wu Weibin, Feng Yunlin, Xu Peng Bo, Zhan Xiaozhi. Pineapple picking mechanization exploration [J]. *the development of modern agricultural equipment*, 2014 (05): 56-59.
- [3] Li Bin, Wang Maohua, Li Li. The field of pineapple fruit identification based on monocular vision [J]. *Journal of agricultural engineering*, 2010, 26 (10): 345-349.
- [4] Wu Weibin, Feng Yunlin, Luo Kuo, Zhan Xiaozhi, Ceng Weipeng, Liao Jinwei, Lu Dihao, Huang

- Tao, Hong Tiansheng. Adjustable gap type pineapple picking truck design and research of [J]. *agricultural research chassis*, 2016,38 (05): 132-137.
- [5] Shi Junxia, Zhang Rihong, Zhu Jingxian. Design and Simulation of pineapple automatic picking machine [J]. *technology information*, 2010 (32): 453-454.
- [6] Zhang Sanchuan, Peng Nan, Li Xia. Structure design and finite element analysis of two wheeled self-balancing electric vehicle [J]. *Journal of Zhengzhou University* (Engineering Edition), 2011,32 (01): 30-33.
- [7] Zheng Weigang. Brief introduction of intelligent robot and development trend [J]. *intelligent robot*, 2016, (2): 41-43.