Structure design of a new carrot grading device

Jian Wang¹, Zhenhua Li¹, * and Junwang Guo²

¹School of mechanical engineering, Zhejiang Ocean University, Zhoushan, China
²School of engineering technology, Tianjin Agricultural University, Tianjin, China

*Corresponding author e-mail: lizh760905@zjou.edu.cn

Abstract. In this paper, aiming at the design of the sorting device for rod-shaped vegetables and fruits, the research status of grading device at home and abroad is analysed, and a variety of grading device mechanisms are compared, and the design scheme of a variety of carrot grading device is determined. Through analogy analysis, a carrot grading device is designed. The grading device is composed of cleaning and feeding device and automatic grading device. The cleaning uniformity device is mainly to put carrots in the pool for cleaning, and then the motor operates, and the conveyor belt with inclined partition starts to work, and the carrots are transported to the grading device through the partition board. The principle of automatic grading device is to grade carrots by adjusting the gap between two adjacent conveyor belts. The gap size is arranged from small to large in order to realize automatic grading according to the diameter of carrots. In this paper, the following aspects are analyzed: by comparing the mechanism of other grading device, the carrot grading device is analyzed and designed. The mechanical part is designed to be three-dimensional using Pro/E modeling, as well as part modeling and assembly. At present, there are some defects in the design of rod-shaped vegetable and fruit grading device in our country. The research has filled the defect and has high practicability.

1. Introduction

Carrot as a vegetable, people like it, especially suitable for the development of industry, because of its high nutritional value, high yield, simple planting, convenient storage and transportation [1-3]. The total scale of carrot production in China is relatively large, accounting for about one third of the world's total production. The export of carrots is mainly sold to Asian countries and the European Union, and a small amount is sold to European and American countries [4]. Among them, Japan is a country with a large number of carrot sales in China, and the number of carrots sold to Japan every year accounts for a large part of the total sales [5].

Nowadays, the research on fruit and vegetable grading in China is relatively backward, and the design of grading device is far behind that of foreign countries. The grading methods are basically semi manual and semi mechanical, which is inefficient and labor-intensive. At present, the main fruit and vegetable grading devices in China include weight type, belt type, roller type, disc type, roller type, etc. [6-10]. These grading devices are only suitable for apple, walnut, jujube, potato and other spherical fruits and vegetables, but not suitable for carrot and other rod-shaped grading [11-12]. Then, after consulting the data, it is found that the grading of rod-shaped fruits and vegetables in China is in the blank stage, which makes the classification time efficient Low cost, labor consumption, affect the economic benefits of the industry [13-14].
In order to solve this kind of problem and fill in the blank of this kind of mechanization in our country, this paper puts forward a kind of carrot grading device, which integrates the functions of cleaning, transportation, grading and packing, which greatly liberates the labor force, transforms the existing semi mechanical and semi manual grading mode into the fully automatic mechanical grading mode, greatly promotes the development of carrot industry, and brings about the development of carrot industry Greater economic benefits.

2. Experimental

2.1. Grading index and characteristics of carrot
Carrot is a kind of similar rod-shaped plant, which has many uses, and can be used in food, medicine, etc. in the design of carrot grading device, the carrot is divided into four grades according to the diameter of carrot: S, M, L and XL. As shown in the table below:

| SIZE | S      | M      | L      | XL     |
|------|--------|--------|--------|--------|
| DIAMETER (MM) | 30-40  | 40-50  | 50-60  | >60    |

2.2. Overall structure and principle of grading device
Carrot grading device mainly includes feeding device and grading device, in which feeding device includes clapboard, inclined conveyor belt, motor and support frame; grading device includes four conveyor belts, motor, frame and aggregate box. The overall structure is shown in Figure 1:

Fig. 1 Schematic diagram of carrot grading device
1 - diaphragm inclination 2 - rubber conveyor 3 - support frame 4 - aggregate box 5 - hopper

2.3. Design of feeding device

2.3.1. Principle of feeding device. The feeding device is composed of an inclined partition conveyor belt and a support frame. Its working principle is to block the carrots through the clapboard, so as to prevent the carrots from rolling down during the feeding process. Therefore, the design is based on the parameters of the separator to ensure that the carrots can be transported to the grading device quickly and without accumulation.

2.3.2. Inclination of inclined conveyor belt. In the feeding device, the tilt angle of the conveyor belt and the height of the partition board on the conveyor belt affect the feeding efficiency. When the inclination angle of the conveyor belt is too large, the baffle can not block the downward trend of carrots. When the angle of the conveyor belt is too small, the feeding device needs to reach a certain height, and the required length of the conveyor belt will be lengthened, resulting in the size of the feeding device too
large. Therefore, in order to ensure the carrot does not fall, but also to consider the size of the overall size, the initial angle is 30 degrees.

2.3.3. Determination of diaphragm parameters. In the feeding device, the clapboard plays a role in fixing carrots and preventing them from rolling. The carrot is regarded as a rod-shaped object, and the carrot tends to roll down on the inclined conveyor belt. The partition gives the carrot a binding force, which makes the carrot rest on the inclined conveyor belt, as shown in Figure 2.

\[ H = D \times (1 - \cos \alpha) \]

In formula: is the height of the clapboard, is the diameter of the carrot, is the tilt angle of the inclined conveyor belt, the initial angle is 30 degrees.

When the minimum diameter of carrot is taken, according to formula, it is obtained that. When the maximum diameter of carrot is taken, according to formula, it is obtained that. Therefore, the height range of the clapboard is 3 mm-12 mm. In order to keep the carrot from falling, the height of the partition board is 12 mm. The length of the partition is the same as the width of the conveyor belt, and the length is 200 mm.

2.4. Design of automatic grading device

2.4.1. Principle of automatic grading device. The automatic grading device is also the core device of the machine. According to the diameter of carrots, the carrots are graded by mechanical means. According to the size of the conveyor belt, the gap between the conveyor belt and the small one should be selected according to the size of the conveyor belt. Secondly, the conveyor belt needs to be wrapped with rubber, which can ensure that the damage of fruits and vegetables can be reduced in the process of grading. The working principle of the device is: when the carrot falls from the feeding device and enters the first conveyor belt of grading, the carrot will reach the first gap with the movement of the conveyor belt, when some small diameter carrots will fall along the gap and enter the aggregate box, when some carrots with a diameter larger than the gap will enter the next gap with the movement of the next conveyor belt until it meets the ratio. The clearance with large diameter makes it fall into the container along the clearance to achieve the purpose of classification.

2.4.2. Belt speed of conveyor belt in machinery. In the process of conveying, there are certain restrictions on the belt speed. If the belt speed is too small in the feeding and grading device, it will directly affect the work efficiency and can not reach the expected goal; if the belt speed is too high, the material will roll in the feeding device, and the classification accuracy will be directly affected in the grading device. After consulting a lot of data, the belt speed is set to 0.3m/s.
2.4.3. **Determination of the size of the intermediate gap in the grading device.** After the carrots fall from the feeding device and enter the first grading conveyor belt, the carrots will reach the first gap with the movement of the conveyor belt. When some small diameter carrots fall down along the gap, they will enter the aggregate box. When some carrots with a diameter larger than the gap will enter the next gap with the movement of the next conveyor belt, they will know that there is a gap larger than their diameter. It will fall into the container along the gap to achieve the purpose of classification. Therefore, the gap between the two conveyor belts should be set. According to the grading specifications of carrots and the diameter, it can be divided into four grades: small (s), too small (m), too large (L) and large (XL). The gap between the conveyor belts should be set as 40mm, 50mm and 60mm in turn. The first gap should be 40mm, and the falling carrot should be s-grade; The second gap is 50 mm, the dropped carrot is m grade; the third gap is 60mm, the falling carrot is l grade; the last falling carrot diameter is greater than 60mm, it is XL grade.

3. **Three dimensional modeling of main components of carrot grading device**

3.1. **Three dimensional modeling of partition conveyor belt**
The clapboard conveyor belt is the core mechanism of the feeding device. According to the determined parameters, such as the inclination angle of the conveyor belt and the height of the clapboard, the 3D modeling is carried out by using the software. The modeling process is as follows: firstly, according to the angle of inclination, two pulleys are stretched out by using the function of stretching, then the mechanism is defined, and the conveyor belt is added to the two pulleys. Finally, the clapboard is pulled out on the conveyor belt according to the height of the partition board, as shown in Fig. 3.

3.2. **Three dimensional modeling of grading conveyor belt**
In order to achieve the purpose and requirements of classification, the gap between each conveyor belt needs to be strictly designed. Firstly, the gap size should be in the order from small to large, and then the size of each gap needs to select the appropriate parameters according to the grading specifications, so the 3D modeling is carried out according to the gap parameters set. The process of modeling is as follows: first pull out two pulleys, then add conveyor belts to the two pulleys by defining mechanism, and then stretch the next conveyor belt according to a certain gap. The gap is from small to large to achieve classification. When modeling the aggregate box, first stretch a cuboid, then use the shell extraction function to empty the cuboid, and then stretch a baffle at the top of the box to reduce the fruit damage rate, as shown in Figure 4.

3.3. **Overall assembly drawing of carrot grading device**
In this paper, the assembly process of carrot grading device, first of all, the device is analyzed to determine which is the default way to install. Secondly, the design and modeling of all parts such as partition inclined conveyor belt, grading conveyor belt, support frame, aggregate box and so on are completed, and then they are assembled around the default parts and saved as the corresponding assembly parts. The virtual assembly of the device is completed. Finally, each assembly is assembled together to complete the general assembly drawing, as shown in Figure 5.
4. Conclusion
This design puts forward a carrot grading device, which integrates the functions of feeding and grading, which greatly liberates the labor force and transforms the existing semi mechanical and semi manual grading mode into fully automatic mechanical grading mode. For carrot grading device, the main research work is as follows:

1. According to the professional knowledge learned, the preliminary calculation of mechanical device data. The inclination of the inclined conveyor belt, the height setting of the clapboard, the gap setting of the conveyor belt, etc.

2. Check the preliminary data and exclude unreasonable data. According to the data obtained, the two-dimensional diagram of the mechanism is sketched out. Check the rationality of the two-dimensional graph and modify the unreasonable data.

3. Based on the calibration data, part of the 3D model is executed using Pro/E. Perfect 3D model, and complete the 3D modeling of parts. Assemble the parts and complete the whole picture.

4. The problem of automatic grading of rod-shaped fruits and vegetables such as carrots was solved.

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