

Design and research of shrimp automatic processing equipment

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Abstract. In view of the lack of shrimp deep processing equipment in my country's aquatic product processing industry, this paper takes *Penaeus vannamei* (hereinafter referred to as shrimp) as the research object. and other key technologies to carry out research, design and develop a new type of shrimp peeling processing equipment. In order to realize the automatic processing of shrimp shell and meat separation, simplify the processing process, reduce manufacturing and production costs, and further improve the economic benefits of shrimp product processing and production.

Keywords: *Penaeus vannamei*, automatic equipment, mathematical model.

1. Introduction

China is a country with a large shrimp production, but the development of China's shrimp processing industry cannot meet the needs of the market, and its processing methods and processing equipment are far behind other countries [1]. At present, the shrimp processing method in China is still in its infancy. The shrimp processing is mainly manual processing or semi-automatic processing. Most of the shrimp products are primary processing, with little finishing processing. The added value of shrimp processing products is low, and the comprehensive utilization of shrimp is not enough [2]. In this paper, through the research and analysis of the existing shrimp processing technology and technological innovation, a multi-functional shrimp deep processing automation equipment is developed, which aims to improve the efficiency and processing scale of shrimp processing and production. Meeting market demands and improving the core competitiveness of processing enterprises has important practical significance and economic value for the healthy development of the shrimp industry.

2. Analysis of functional requirements of shrimp processing equipment

The main steps of shrimp processing are generally to remove the shrimp head, open the back, remove the shrimp line and separate the shell and meat. At present, the existing shrimp processing equipment in China has a single function, and most of them can only process one of the processing links, and the processing effect is poor. Lack of deep shrimp equipment [3]. Developed an automatic shrimp processing equipment that integrates directional sorting, shrimp head removal, back opening, shrimp line removal and shell and meat separation functions, which can realize mechanization, automation, intelligence, deepening and scale of the entire processing process.

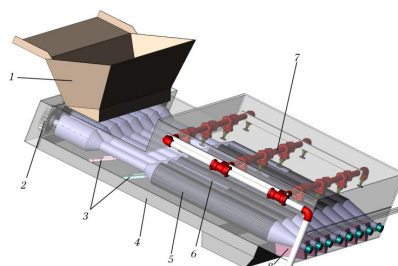
3. Modular design of shrimp processing equipment

The spatial layout of the shrimp processing equipment is modularly designed from top to bottom according to the processing flow, and its order is the orientation module; the shrimp head removing module; the back opening and shrimp thread removing module; the shelling module [4]. Its advantages are to facilitate the effective connection between various processing modules and to simplify the space structure of the equipment.

3.1 Orientation sorting module

The directional ordering of prawns is to lay the foundation for the subsequent processing links. Based on the body shape and friction characteristics of prawns, a directional mechanism is designed to complete the directional sorting of prawns. The directional sorting of prawns is continuously output in the posture of shrimp head in front and abdomen up.

The directional sorting device is mainly composed of a feeding port, a set of directional sorting rollers, a gear transmission system, a water spray system, an auxiliary directional system, and a frame. The directional sorting roller set is composed of two different rollers. In order to better orient the prawns, the directional sorting rollers are placed obliquely on the rack, with several rows of water spraying devices installed above the rollers and a jet auxiliary orienting device installed below.



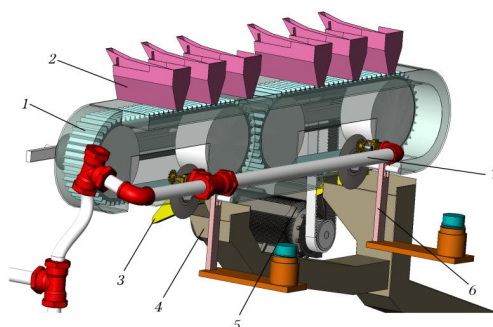
1. Feeding port; 2. Transmission gear; 3. Orientation auxiliary device; 4. Bottom plate; 5. Orientation roller I; 6. Orientation roller II; 7. Spray device;

Figure 1 Orientation sorting module

3.2 Remove the shrimp head module

Based on the friction and centrifugal force generated when the disc blade cuts prawns, a high-speed disc blade deheading device is designed. Its function is also to lay the foundation for the separation of shrimp shell and meat.

The high-speed disc knife shrimp deheading device is mainly composed of a frame, a deheading mechanism, a conveying and feeding mechanism, a water spray device, etc. The most important of which is the design of the deheading mechanism and the conveying and feeding mechanism. Based on the body shape characteristics and biological characteristics of shrimp, combined with the requirements of decapitation, a conveyor belt with a "V"-shaped groove is designed. The "V"-shaped groove cooperates with the baffle to complete the positioning and clamping of the shrimp, and the conveyor belt can be Driven by the motor, it rotates, and the position where the shrimp is positioned and clamped is the shrimp body, and the shrimp head is exposed for easy cutting. The prawns are positioned and clamped on the top of the conveyor belt, and then transported to the bottom to cooperate with the blade mechanism to complete the deheading.



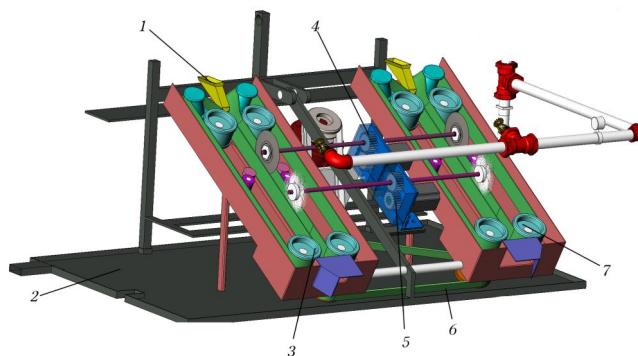
1. Clamping conveyor belt; 2. Transition device I; 3. Transition device II; 4. Shrimp head collection pipe; 5. Motor; 6. Blade height adjustment device; 7. Spray device

Figure 2 Shrimp head removal module

3.3 Open back, remove shrimp line module

Shrimp back-opening and de-shrimp line are both indispensable links in the shrimp processing process. The effect of shrimp back-opening is directly related to one of the key factors in whether the shrimp peeling process can be accomplished through mechanical equipment.

The device for opening the back and removing the shrimp line is mainly composed of a frame, a clamping and conveying mechanism, a back opening mechanism, a mechanism for removing the shrimp line, and a water spraying mechanism. In order to be able to connect and de-head the machining process, the device is placed on the frame at an angle. The clamping and conveying mechanism is composed of a flat belt, a transmission wheel and a tensioning wheel, mainly for clamping and transporting prawns; the back-opening mechanism is composed of a disc blade, a transmission shaft and a motor, and an opening is mainly drawn on the back of the prawns; The shrimp line mechanism is composed of a brush drive shaft and a motor, mainly to clean the shrimp line leaking out of the back opening. In order to adapt to more processing scenarios, both the back opening mechanism and the shrimp line removing mechanism can be adjusted in height to control the opening depth. The tensioning wheel ensures the correct clamping position of the prawns.



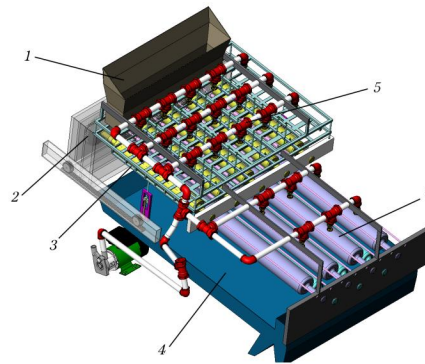
1. Transition device II; 2. Rack; 3. Outlet; 4. Back opening mechanism; 5. Shrimp line removal mechanism; 6. Transmission belt; 7. Driving wheel

Figure 3 Open the back and remove the shrimp line module

3.4 Shell module

The separation of shell and meat of prawns is the final step of prawn processing. On the basis of the roller type, a rolling, kneading and extruding flexible shelling equipment is designed, which is mainly divided into a kneading and extruding mechanism and a shelling mechanism [5] .

The roller type kneading flexible shrimp shelling equipment is mainly composed of a feeding port, a power mechanism, a kneading and extrusion mechanism, a shelling mechanism, a water spray mechanism, a discharge port, and a rack. In order to allow the prawns to slide down in the rollers, the entire equipment is placed at an angle on the rack. From the structural point of view, the equipment can be divided into four layers. The first layer is a convex rolling mechanism, and the other three layers are roller layers with different numbers. The first layer of rolling and the second and third layers of rollers cooperate to complete the prawns. The 3rd and 4th layers of rollers cooperate to complete the shelling of the prawns.



1. Feeding port; 2. Extrusion and kneading mechanism; 3. Axis I; 4. Axis IV; 5. Bottom plate; 6. Axis III; 7. Axis II; 8. Spray device; 9. Transmission gear

Figure 4 Shelling module

3.4.1 Kneading and squeezing mechanism.

Before the official shelling, the prawns that have been removed from the head and their backs need to be fully rolled and rubbed in the rubbing and squeezing mechanism before shelling, which can improve the efficiency and effect of shelling [6] .

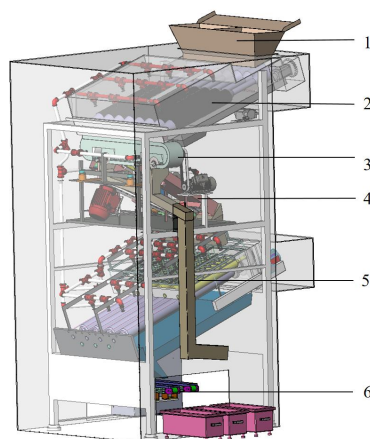
The mechanism is mainly composed of a rolling mechanism and a rubbing roller group. The rolling mechanism consists of a rolling contact table, a buffer spring, a power mechanism, and a rolling frame; The rolling contact table realizes up and down reciprocating motion driven by the reciprocating rotation of the rack and pinion. When the prawns move to the bottom between the rollers, the rolling contact table will squeeze the prawns. The roller shaft I and the roller shaft II in the rubbing roller group are placed in parallel in a "V"-shaped groove, the roller shaft III is located in the gap of the "V"-shaped groove, and the roller shafts I and II are driven by the motor to achieve opposite rotation.

3.4.2 Shelling mechanism.

The mechanism is mainly composed of rollers. The upper two rollers and the lower one form a "V"-shaped groove. The whole mechanism is shown in the figure. The rollers II and IV have the same diameter, the same length and are placed in parallel. The working principle and structure of the shelling mechanism are similar to those of the kneading and squeezing mechanism, except that the rolling mechanism is missing. The roller shafts II and IV are driven by the motor to reciprocate and rotate in opposite directions. After kneading and squeezing, the shrimp shells and shrimp meat are separated in the "V"-shaped groove of the roller shaft in the shelling mechanism.

3.5 Overall 3D model

The overall three-dimensional model of the shrimp automated processing equipment is shown in Figure 7.



1. Feeding port; 2. Orientation sorting module; 3. Shrimp head removing module; 4. Back opening and shrimp thread removing module; 5. Shelling module; 6. Material outlet

Figure 5 Overall 3D model of the equipment

4. Conclusion

The shrimp processing equipment integrates the functions of directional sorting, removing the shrimp head, opening the back, removing the shrimp line, separating the shrimp shell and shrimp, conveying, collecting and other functions in the process of shrimp shelling, which improves the efficiency of shrimp processing; The machinery is integrated into a whole machine, which simplifies the mechanical structure, reduces the manufacturing cost, and improves the mechanization level of shrimp processing and production in my country, which has huge market application value.

5. Acknowledgments

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References

- [1] Ouyang Jie, Shen Jian, Zheng Xiaowei, et al. Status and development trend of research and application of aquatic product processing equipment [J]. *Fishery Modernization*, 2017, 44(5): 73—78.
- [2] Yi Jinggang, Ma Junyuan, Wang Zehe, Zhang Xiuhua, Yang Shuhua. Status and development of shrimp processing equipment [J]. *Modern Agricultural Equipment*, 2020, 41(01): 2-11.
- [3] Xiong Shi, Li Jia, Zhou Liming, Chen Yuanhui, Bai Shenghe, Fang Constitution. Design and experiment of control system of roller type shrimp sheller [J]. *Journal of Agricultural Machinery*, 2021, 52(S1): 457-465.
- [4] Zhang Xiuhua, Su Yuefeng, Yi Jinggang, Wang Zehe, Yang Shuhua. Experimental study on the effect of rubbing pretreatment on shelling of *Penaeus vannamei* [J]. *Chinese Journal of Agricultural Engineering*, 2021, 37(08): 307-315.
- [5] Jin Jin, Xu Pengyun, Yuan Xingmao, Wang Zehe. Design and research of shrimp shelling equipment [J]. *Agricultural Mechanization Research*, 2014, 36(09): 134-137.
- [6] Zhao Yuda, Zhang Xiuhua, Wang Zehe, Yi Jinggang, Liu Jiangtao. Discussion and Research on Mechanical Shelling Technology of Prawns [J]. *Agricultural Mechanization Research*, 2014, 36(07): 42-45.