Journal of Electronics and Information Science (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/jeis.2025.100211
ISSN 2371-9524 Vol. 10 Num. 2

The Design of the Integrated Continuous Fish Killing Machine

Zimeng Li[1,a], Guochun Wang[1,b], Chenghui Liao[1,c], Wei Lu[1,d], Xingming Fan[1,e,*]

[1]Guilin University of Electronic Technology, Guilin, 541004, Guangxi, China
[a]15120007775@163.com, [b]1978141247@qq.com, [c]3011869369@qq.com, [d]lujunqi2001@163.com, [e]jiahuiyuyao@163.com
[*]Corresponding author

Keywords: Fish Killing Machine, Fish Scale Removal, Modular Design, Stress Analysis

Abstract: This study aims to design an all-in-one continuous fish killing machine suitable for small and medium-sized enterprises or catering industry to improve production efficiency and reduce labor intensity. The modular mechanics are optimized by integrating descaling, cutting, gutting and collection functions, and are powered by electric drives. Experimental results show that the machine can significantly improve processing efficiency, reduce labor costs, and adapt to a variety of fish. This product research provides a new solution for the automation of aquatic product processing.

1. Introduction

In recent years, with the rapid development of fresh e-commerce and prepared food markets, consumers' requirements for aquatic product processing efficiency and hygiene standards have been increasing. As a source of high-quality protein, the market demand for fish continues to grow, and the low efficiency and high health risks of traditional manual treatment methods have become a bottleneck restricting the large-scale development of the industry [1]. As the world's largest consumer of aquatic products, our country has a huge scale of aquatic product processing, but the fish killing process is still highly dependent on manual labor, facing challenges such as rising labor costs and low standardization of operations.

In developed countries, such as Japan, Germany, and the United States, the technology of fully automatic fish killing equipment is relatively mature, which can achieve efficient scaling, precise back opening, and visceral cleaning, and the processing efficiency can reach more than 400 fish per hour, with a high degree of automation [2]. For example, Japan uses laser descaling and vacuum adsorption technology, and Germany relies on multi-sensor collaboration and 3D scanning systems to achieve high-precision operation, with a visceral cleaning rate of more than 97%. However, foreign equipment is expensive (more than 500,000 yuan per machine), strict requirements for fish fingerlings and fish body size, and requires constant temperature environment or pre-cooling treatment, which is difficult to adapt to the market reality of our country's small and medium-sized enterprises, multiple fish species, and direct processing of live fish, and the compatibility and economy are poor [5].

2. Scheme design

2.1 Overall scheme design

By integrating multi-functional modules such as scaling, back, and gutting, combined with high-pressure water cleaning and adaptive mechanical structure [4, 10], this product can achieve efficient and precise treatment of multiple fish species, significantly improving the automation level and hygiene standards of aquatic processing [11]. The equipment has a simple structure and controllable cost, which is not only suitable for large-scale processing enterprises, but also takes into account the practical needs of small and medium-sized fish processing enterprises and the catering industry, which can greatly reduce labor costs and operational risks and improve product quality consistency.

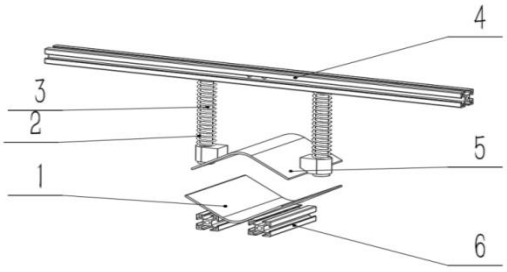
This product mainly includes descaling system, propulsion system, cutting system, gutting system, collection system, drive system and other modules.

2.2 Descaling system

This product is innovatively designed to efficiently descale fish of various sizes [2, 13].

The descaling system of this product includes the fish inlet, the first continuous spring descaler, the second continuous spring descaler, and the upper and lower descaling mechanism.

This product features an innovative fish inlet design, as shown in Figure 1. including lower v-shaped iron plate, plate support rod, spring, top strut, upper V-shaped plate, lower plate bracket; The lower V-shaped iron plate is fixed on the lower plate support, the lower plate bracket is fixed and connected with the main frame body, the upper side of the lower V-shaped iron plate is set with the upper V-shaped plate, the two ends of the upper V-shaped plate are fixed and connected with the lower end of the two plate support rods, a set of springs are connected to the outside of the plate support rod, the upper end of the two plate support rods is connected with the bottom of the top strut, and the top strut is installed on the main frame body. The size of the fish inlet can be adjusted by moving the V-iron plate to accommodate the entry of fish of different sizes.



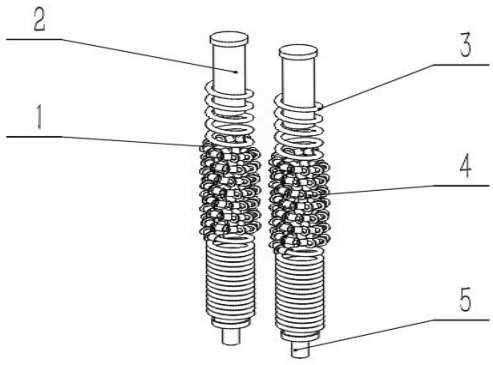
1-Lower V-shaped iron plate, 2-Spring, 3-Plate support rod, 4-Top strut, 5-Upper V-shaped plate, 6-Lower plate bracket

Fig.1 Fish inlet

The descaling device adopts a two-module design:

1) Continuous spring descaler: as shown in Figure 2. continuous spring descalers include the first continuous spring descaler and the second continuous spring descaler. The structure of the first continuous spring descaler and the second continuous spring descaler is the same, both include the descaling slide, the upper support shaft, the spring, the spring with the descaling slide, and the lower support shaft. The spring of the two spirals is socketed with several descaling slides, and a spring with a descaling slide is provided between the several descaling slides, and the upper end of the spring is connected with an upper support shaft, and the lower end of the spring is fixed with a lower support shaft. The core is a descaling roller with a spiral wound stainless steel spring, which significantly

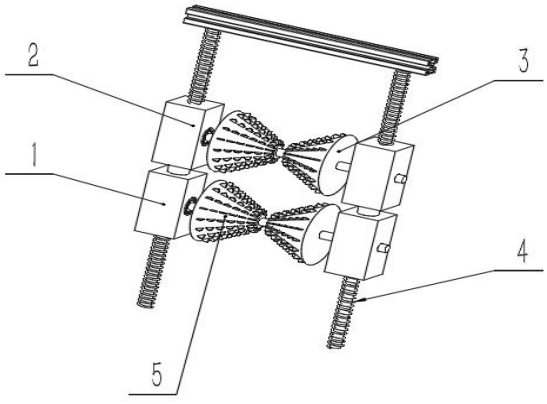
improves the scraping efficiency by optimizing the spring parameters and rotational speed [2]. The spring is in high contact with the fish body, combined with the upper and lower double roller layout, which can remove the scales on both sides of the fish body at one time.



1-With descaling slide spring, 2-Upper support shaft, 3-spring, 4-Descaling slide, 5-Lower support shaft

Fig.2 Continuous spring descaler

2) Upper and lower descaling mechanisms: as shown in Figure 3. The upper and lower descaling mechanisms include a slide block, an upper slider, an upper cone descaler, a spring four, a lower cone descaler, and a movable shaft. The two movable shafts are movably connected with a slider and an upper slider, and the upper and lower sides of the movable shaft are socketed with springs, and the two ends of the shaft of the lower tapered descaler are installed in the rotating hole between the two sliders, and the two ends of the shaft of the upper tapered descaler are installed in the rotating hole between the two upper sliders. For areas prone to residues such as the top and bottom of the fish body, the device adopts a symmetrical conical design with fine scale lines or bulges on the surface. The fish body with the left and right scales removed is placed between the two cones by pushing the device, and the friction and scraping structure on the surface of the cone are used to quickly remove the scales on the upper and lower sides of the fish body [13]. The double-cone design can adapt to different fish sizes, improve efficiency by simultaneous operation up and down, and avoid the risk of scratches on the hands of traditional descaling tools, further remove stubborn scales, and ensure that there are no dead ends in descaling.



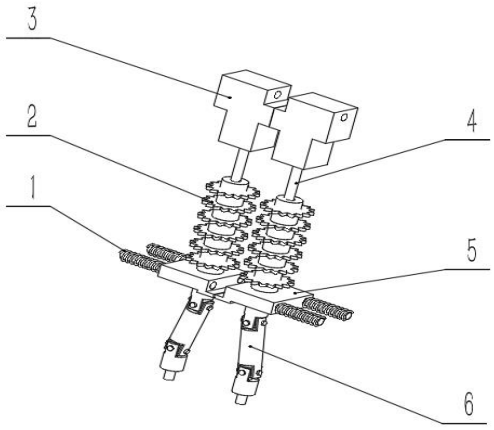
1-slide block, 2-upper slider, 3-upper cone descaler, 4-spring four, 5-lower cone descaler

Fig.3 Upper and lower descaling mechanisms

The two modules operate synchronously, taking into account both efficiency and comprehensiveness. In addition, the parametric design allows the equipment to be flexibly adapted to different fish species, providing an efficient solution for fish processing automation [10].

2.3 Propulsion system

This product features an innovative push mechanism, including a first gear push mechanism and a second gear push mechanism, as shown in Figure 4. the first pushing gear mechanism and the second pushing gear mechanism have the same structure, both comprising a spring, a serrated gear, an upper slider, a connecting shaft, a slide block, a universal joint, and a movable shaft; The inner side of several movable shafts is movably connected in the movable holes of the side walls of the two upper sliders and two sliders, and the outer ends of several movable shafts are fixed and installed on the main frame body, the outer side of the movable shaft is socketed with a spring, and the connecting shafts are fixed and installed between the two upper sliders and the two sliders, and several serrated gears are evenly installed on the two connecting shafts, and the bottom of the slide block is fixed and installed with universal joints. Dynamically adapts to different sizes of fish bodies to ensure that the fish bodies are smoothly transported forward according to the preset spacing, avoiding stacking or offset, and at the same time preventing the fish body from being squeezed or deformed or sliding, ensuring the accuracy of the cutting position.

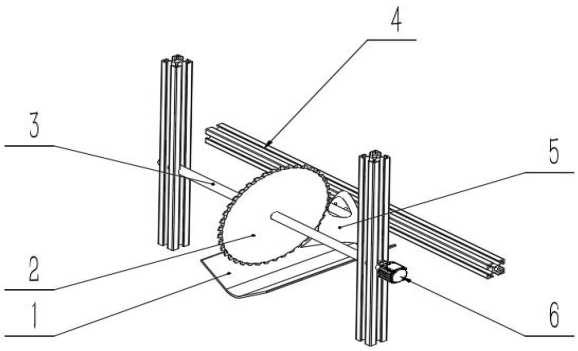


1-Spring, 2-Saw gear, 3-Upper slider, 4-Connecting shaft, 5-Slider, 6-universal joint

Fig.4 Push system

2.4 Cutting system

The cutting system of this fish killer integrates the serrated knife set and the separation device to realize the automation of the whole process of precise cutting and pretreatment of the fish body. The serrated knife set includes a rotary shaft, a serrated knife, and a cutting motor; The sawtooth knife is fixed and installed on the rotating shaft, which is installed in the mounting hole of the main frame body through bearings, and one end of the rotating shaft is connected with the shaft of the cutting motor, and the cutting motor is fixed on the main frame body. The separation device includes a support V-shaped iron plate, a bracket, a fish body distribution head, and a bracket; The bottom and sides of the supporting V-shaped iron plate are equipped with brackets, and the middle and upper side of the supporting V-shaped iron plate are equipped with fish body distribution heads, which are fixed on the brackets, and the brackets and brackets are installed on the main frame respectively. Through modular collaborative operation [10], the system ensures efficient and coherent fish body disembowelment and slitting, providing a standardized operation basis for subsequent gutting and significantly improving processing efficiency and finished product quality. The overall figure is shown in Figure 5:



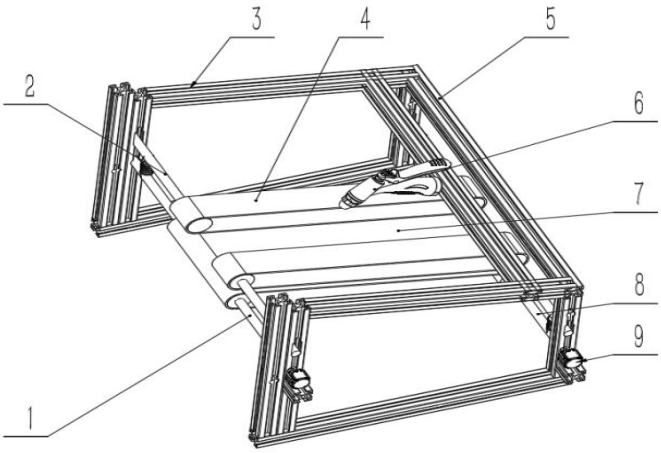
1-Support V-shaped iron plate, 2-Serrated knife, 3-Bracket rotary shaft, 4-Bracket, 5-Fish body distribution head, 6-Cutting motor

Fig.5 Cutting system

Sawtooth knife set: The high-precision stainless steel sawtooth blade is designed in a wavy shape [14], and it rapidly cuts along the midline of the fish's abdomen in a high-frequency vibration mode. The cut is smooth and the depth is controllable, fully preserving the meat on both sides of the fish body and reducing fish meat loss. Separation device: After cutting, the fish body is symmetrically unfolded along the cut, and the fish body is stretched to a fixed Angle to fully expose the internal organ chambers The separation action is linked with the internal organ removal system to ensure the unobstructed path for internal organ removal and avoid residue problems caused by incomplete opening [7], laying the foundation for efficient cleaning.

2.5 Gut the system

The gutting system of this product is composed of a conveying and pressing conveying mechanism and a high-pressure water gun, as shown in Figure 6. The conveying and pressing conveyor mechanism includes external transverse frame, external longitudinal frame, mounting shaft, pressing belt, conveyor belt, drive shaft, pull spring, sliding groove, and transmission motor; The four corners of the external transverse frame are fixed and installed with external longitudinal frames, the front and rear sides of the external longitudinal frame are installed with drive shafts through bearings, the belt rollers of the two drive shafts are connected by the conveyor belt, one end of the drive shaft is connected with the shaft of the transmission motor, the transmission motor is fixed on the outer side wall of the external longitudinal frame, one end of the four mounting shafts is movably connected in the sliding groove on the external longitudinal frame, the inner ends of the four mounting shafts are connected with belt rollers, and the front and rear belt rollers are connected by pressing the belt. There is a cleaning gap between the two pressing belts, and the four mounting shafts are connected to the drive shaft by means of a pull spring. Efficient removal of fish internal organs through automated processes is both precise and environmentally friendly [7]. The cut fish body is transported to the gutting station by the conveyor belt at a uniform speed, and the conveyor belt is equipped with adjustable elastic strips on both sides to fix the fish body through flexible clamping to avoid the impact of high-pressure water flow causing the fish body to shift or slip, and ensure the stability of the washing position. The layering is made of food-grade silicone material, which is suitable for different fish body widths, which not only protects the integrity of the fish skin but also achieves damage-free fixation. Multiple sets of high-pressure water guns spray high-speed water into the fish's body cavity to quickly peel off and wash away internal organs, blood film, and other residues [3]. At the same time, the water flow parameters are adjustable, adapting to the visceral structure of different fish species such as crucian carp and grass carp to ensure thorough cleaning without damaging the fish fibers.

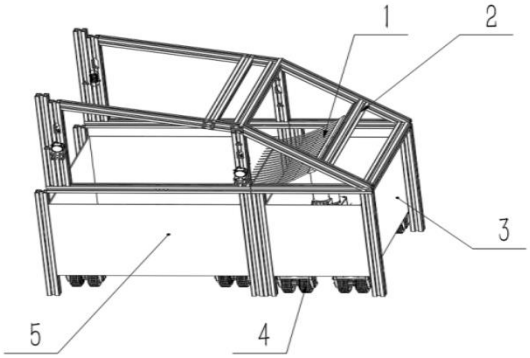


1-Drive shaft, 2-Mounting shaft, 3-External longitudinal frame, 4-Press belt, 5-External transverse frame, 6-High pressure water gun,7-Conveyor belt, 8-Bottom conveyor belt linkage, 9-Conveyor motor

Fig.6 Gut system

2.6 Collection System

The collection device consists of a separating fork mechanism and a collection box. The whole is shown in Figure 7. The separating fork mechanism includes a separating fork and a fork frame, which is fixed on the main frame and fixed on the fork frame. The gutted fish and the separated guts are conveyed to the filter along the conveyor belt. The fish is filtered into the inner box, and the internal organs are filtered through the filter to the outer box for collection.



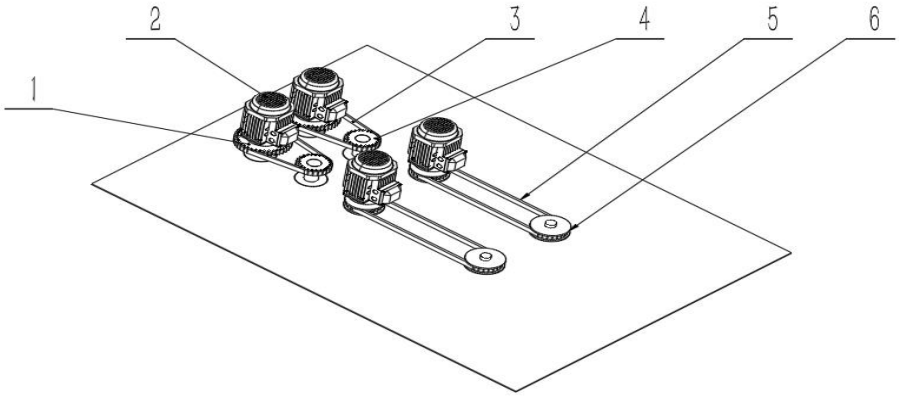
1-Separation fork, 2-Fork rack, 3-Visceral collection box, 4-Pulley, 5-Fish body collection box

Fig.7 Collection system

2.7 Drive System

The drive system includes timing pulleys, stepper motors, timing belts, small wheels, and timing belts, as shown in Figure 8. The two timing pulleys are connected to the bottom of the first continuous spring descaler, the two small wheels are connected to the bottom of the second continuous spring descaler, the timing pulley and the pulley are connected by the timing belt, the shaft of the stepper motor is connected to the timing pulley, the four pulleys are connected to the bottom of the first pushing gear mechanism and the second pushing gear mechanism, the two small wheels are connected through the timing belt, and the shaft of the stepper motor is connected to the small wheel. The drive system uses two stepper motors to accurately control the descaling and pushing actions [6], and uses

synchronous belt drive to ensure the coordinated operation of all components [12], which not only has high processing efficiency and adapts to different fish species, but also has a compact structure, stable operation, and easy maintenance, which can meet the needs of long-term and high-intensity operations in aquatic processing workshops, and significantly improve the automation and reliability of the fish killing machine [1].



1-Timing pulley, 2-stepper motor one, 3-Timing belt one, 4-Small wheel one, 5-Timing belt two, 6-Small wheel two

Fig.8 Drive system

2.8 Motor selection of drive system

The parameter selection and specification determination of the three-phase asynchronous motor in the drive system are shown in Table 1.

Table 1 Parameter selection and specification of electric motors

Parameter	Three-phase asynchronous motor	Unit	Remark
motor power	2.2	kW	The continuous output capacity of the motor is the core parameter of selection
Rated Speed	1450(supposed)	r/min	Common AC motor ranges
Output Torque	14.5	N m	Calculate based on T=9550P/n
Transmission Efficiency	0.8	-	Typical Belt/Gear Drive Values
Safety Factor	1.5	-	Common allowance for industrial design

Output Torque Calculation:

$$\boldsymbol{T = 9550 \times \frac{P}{n}} \tag{1}$$

This torque is the output value of the motor shaft, which is calculated to be 14.5, and the actual torque of the descaling mechanism will increase due to the reduction ratio after the belt transmission (if the reduction ratio i=2, it is the torque of the mechanism).

Load power verification:

After considering the transmission efficiency and safety factor, the actual required motor power is:

$$\boldsymbol{P_{Motor} = \frac{P_{Load}}{\eta} \times k} \tag{2}$$

Assuming that the power P_{load} required by the descaling mechanism = 1.8 kW, the theoretical

power of the motor is 3.375kW, but the actual selection of a 2.2 kW motor indicates that the load of the descaling mechanism is light (possibly due to the small friction coefficient of fish scales), or the motor often operates under partial load.

2.9 Static stress analysis of descaling mechanism

When the fish enters the descaling mechanism on both sides from the fish inlet, due to the action of the fish body on the spring, the spring is deformed to both sides, and the main load is concentrated at the connection between the spring and the upper and lower fixed columns. In order to analyze the potential failure points of the spring, a comprehensive modeling and static stress analysis of the spring was carried out. In the process of static stress analysis (as shown in Fig.9.), the upper and lower fixed columns and the upper and lower parts of the spring are fixed, and a force of 20N is applied to the middle area of the spring to achieve a complete strain state [8].

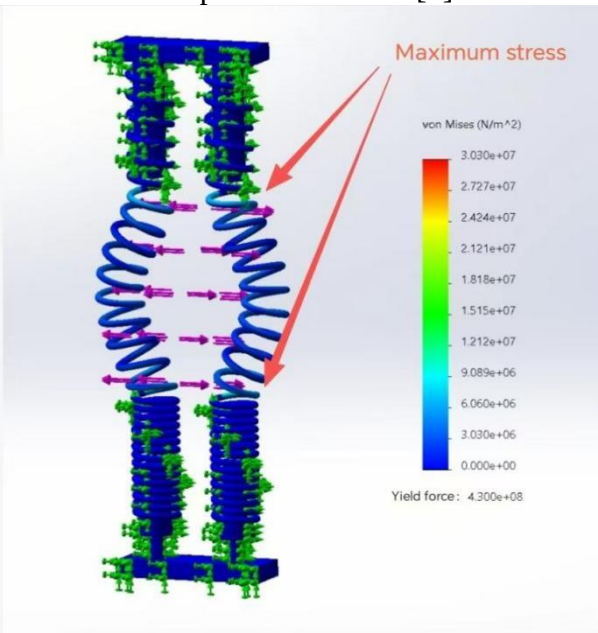


Fig.9 Static analysis of descaling springs on both sides

3. Product features and advantages

Compared with prior technologies, this product is characterized by its integrated structure, which combines the fish inlet, the first and second continuous spring descalers, the first pushing gear mechanism, the upper and lower descaling mechanism, the second pushing gear mechanism, the serrated knife set, the separation device, the high-pressure water gun, the conveying and pressing mechanism, the separation fork mechanism, the visceral collection box, the fish body collection box, the drive system, and the main frame. This integrated design enables the entire process - from fish feeding, descaling, and gutting to cleaning, separation, and collection - to be carried out automatically [1,5]. It reduces manual intervention, ensures precise operation, significantly saves time and cost, and makes the treatment process efficient and smooth. It is particularly suitable for the continuous processing of large quantities of fish [10]. The specific advantages are as follows:

1) This product adopts a fish inlet to enter fish bodies of different sizes, and realizes the descaling through the first continuous spring descaler and the second continuous spring descaler, while the first continuous spring descaler and the second continuous spring descaler use different rotational speeds to achieve a high-efficiency descaling process [2,13].

2) In this product, a serrated knife set is used to dissect the abdomen, and the open fish body is distributed through a separation device, so that the optimal edible part of the fish body is completely retained to form a whole piece of structure, which is conducive to the subsequent continuous and rapid entry into the conveying and pressing conveyor mechanism for the next related processing [5].

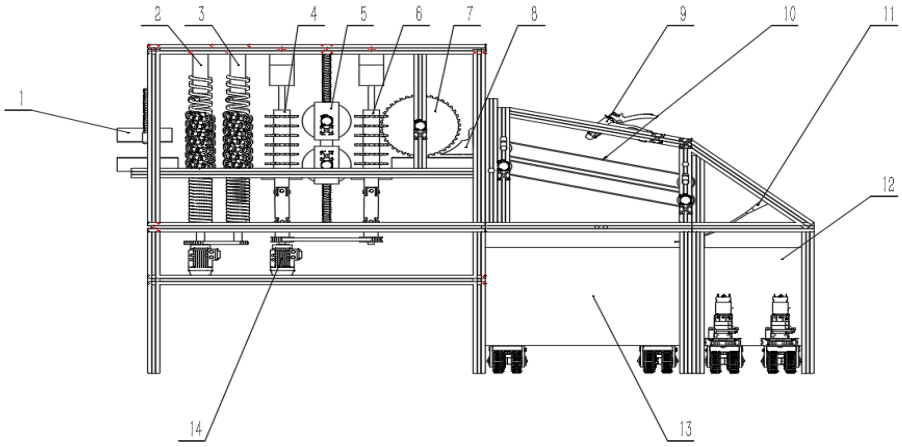
3) This product realizes the pressure and transportation of the fish body through the conveying and pressing conveying mechanism, and cleans it by high-pressure water gun, so that the fish body and internal organs are peeled off, and the peeling effect is thorough [3,7].

4) This product adopts a separating fork mechanism to separate the internal organs into the visceral collection box, and the separating fork mechanism introduces the fish body into the fish body collection box.

5) The mechanical structure of this product is simple, easy to maintain and clean, and adopts an integrated descaling and gutting device, which has comprehensive functions and high safety factor [4,11]. At the same time, it solves the two major problems of removing scales and internal organs in the process of fish treatment, improving work efficiency and saving costs [1].

4. Conclusion

Through a highly integrated modular design [10], the overall structure of this product is shown in Figure 10, and an intelligent fish killer integrating descaling, gutting, cleaning, and collection functions has been successfully created, which accurately meets the urgent market demand for efficient integrated processing equipment [1]. At the same time, the product innovatively adopts an automatically adjustable fish inlet, an adaptive push device [4,9], and a continuous conveyor system, which can flexibly adapt to different sizes and species of fish carbodies, effectively improving the processing efficiency and automation level, reducing labor costs and operational difficulties, and providing a comprehensive and reliable solution for the aquatic product processing industry [5].



1-Fish inlet, 2-1st continuous spring descaler, 3-2nd continuous spring descaler, 4-1st gear pushing mechanism,5-Up and down descaling mechanism, 6-Second gear pushing mechanism, 7-Serrated knife, 8-Fish body splitting head, 9-High pressure water gun,10 - Conveyor belt, 11 - Separation fork, 12 - Visceral collection box, 13 - Fish body collection box, 14 - stepper motor

Fig.10 Overall structure

Acknowledgement

This work was supported by the Autonomous Region-Level College Students' Innovation and Entrepreneurship Training Program (S202510595171).

References

[1] Ge Gaorong, Yu Yizhi. The "Code" of Transformation of Aquatic Products Processing Industry[N]. Zhoushan Daily, 2022-11-14.

[2] Mo Shengqiu. A fish descaling ripper: CN201320083778.4[P]. 2013-07-24.

[3] Liu Qi. Application and prospect of high-pressure water jet technology[J]. Association for Science and Technology Forum (Second Half of the Month), 2013(7): 127-128.

[4] Wang Haiyan. Integration and Application of Informatization in Food Intelligent Processing Technology[J]. Food & Machinery. 2025, 41(4).

[5] Feng Lu, ZHU Congrong, LU Xiaoguang. Design of Control System of Automatic Fish Killer Based on PLC[J]. mechanical engineer, 2015(9): 41-43.

[6] Guo Jianliang. Design of Stepper Motor Control System Based on PLC[J]. Electrical technology, 2025(14): 13.

[7] Li Rujun. Application of Fish Scale Removal and Visceral Processing Machine for Specific Fish[D]. Tianjin: Hebei University of Technology, 2016.

[8] Chen Hua, Zhang Hua, Yu Heng. Design and Research of a Universal Small Fully Automatic Fish Killer[J]. Automation Application, 2022(05):137-139.

[9] Ouyang Jie, Shen Jian, Zheng Xiaowei, et al. Research and Application Status and Development Trend of Aquatic Products Processing Equipment[J]. Fisheries modernization, 2017, 44(05).

[10] Ministry of Agriculture and Rural Affairs of the People's Republic of China. SC/T 6047-2011, Safety and hygiene requirements for peeling, peeling and defilming machinery of food processing machinery (fish)[S]. Beijing: China Agricultural Press, 2011.

[11] Fu Jiannan, Li Guofu, Ye Cunhao. Simulation and Analysis of Meshing Stress of Timing Belt Teeth[J]. Mechanical strength, 2023, 45(03).

[12] Wei Liang, Li Lu, Ma Ruofei, et al. Research progress on key technologies of primary fish processing equipment [J]. modern agricultural equipment, 2023, 44(01): 10-15.

[13] Yu Xunqian. Selection of stainless steel for food machinery and equipment[J]. Packaging & Food Machinery, 1998(02): 34-37.