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# *Design and Verification of A Restaurant-Kitchen Waste Disposal Machine and Its Screw Extruder*

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***Keywords:*** Restaurant-Kitchen Waste, Small and Medium-Sized Restaurant-Kitchen Waste Disposal Machine, Screw Extruder, Discrete Meta-Analysis

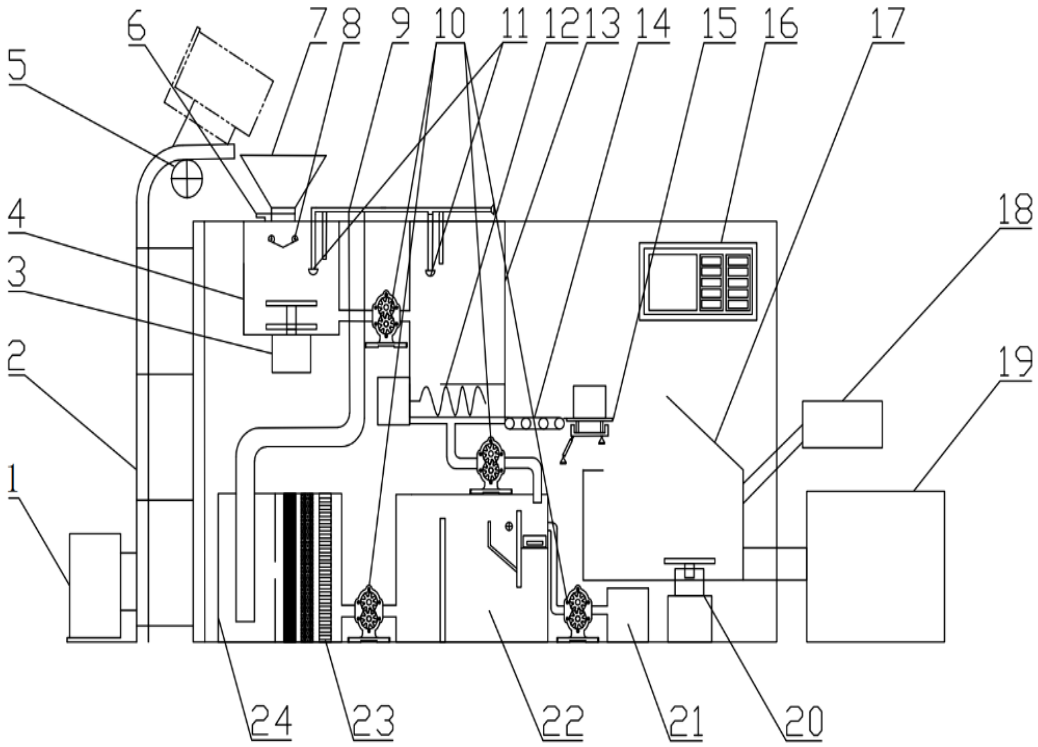
***Abstract:*** China's restaurant-kitchen waste production is huge, with high water content, complex components and other characteristics, if not properly handled, will cause serious environmental pollution. Through reasonable policy guidance and technological innovation, the scientific treatment of restaurant-kitchen-waste can not only reduce environmental pollution, protect the ecological environment, but also realize the efficient use of resources, and promote the sustainable development of the city. First of all, this paper summarizes the overall function of the designed restauant-kitchen waste disposal machine. On this basis, it focuses on the design and improvement of the core component of the reducer screw extruder, chooses the appropriate material, carries out the rational design of the structure, and makes the prototype, conducts the experimental test on the performance parameters of the prototype, and briefly analyzes the results. The effects of screw extruder filling rate, screw rotation speed and mounting elevation on extruding effect of solid food waste were mainly tested, and the best operating parameters were tried to be found out. Finally, a reasonable outlook is given for the future upgrading of the product. First of all, this paper summarizes the overall function of the designed kitchen waste treatment machine. On this basis, it focuses on the design and improvement of the core component of the reducer screw extruder, chooses the appropriate material, carries out the rational design of the structure, and makes the prototype, conducts the experimental test on the performance parameters of the prototype, and briefly analyzes the results. The effects of screw extruder filling rate, screw rotation speed and mounting elevation on extruding effect of solid food waste were mainly tested, and the best operating parameters were tried to be found out. Finally, a reasonable outlook is given for the future upgrading of the product.

## 1. Introduction

With the rapid development of China's economy, China's annual production of kitchen waste is huge, about 195 million tons [1]. Restaurant-kitchen waste refers to food waste produced by hotels, restaurants, enterprises and institutions, and kitchen waste produced by leftovers in residents' daily life. Its main components include rice and flour food residues, vegetables, animal and plant oils, fish, meat and bones, etc [1]. Look from the chemical composition, eat hutch garbage contains a lot

of organic matter, such as starch, cellulose, protein and lipids, etc., and has a high water content, easy to corruption, deterioration and breeding pathogenic microorganisms, cause serious environmental pollution, rotten odor, pathogens will also harm human health, therefore, need to effectively treatment of food kitchen waste.

There are three principles for solid waste disposal in China: harmless, reduction and recycling. On the basis of ensuring the harmless treatment process, improve the effect of reduction and resource recovery. At present, the main treatment technologies of restaurant-kitchen-waste include mechanical crushing, sanitary landfill, incineration power generation, anaerobic fermentation, aerobic composting, etc. Among them, mechanical pretreatment + anaerobic digestion is favored by the restaurant-kitchen-waste treatment plant due to the high degree of harmless and stable process [2]. China started late in the restaurant-kitchen-waste treatment technology, but based on the strong industrial production capacity, has achieved industrial application in a variety of treatment technology and treatment equipment, a variety of large centralized treatment equipment and treatment technology in major cities, to effectively solve the problem of restaurant-kitchen-waste environmental pollution in China. This paper first introduces a small and medium-sized restaurant kitchen waste disposal machine suitable for community and unit canteen users. The following focuses on solving the design and verification problems of its core component screw extruder, which provides a useful reference for the harmless, reduction and resource treatment of restaurant-kitchen waste in China.




1. feeding barrel 2. feeding mechanism 3. crusher 4. crushing box 5. rolling device 6. regulating valve 7. hopper 8. Cutting device 9. Water injection device 10. Gear pump 11. spherical cleaning peng head 12. screw extruder Solid-liquid separation box 14. transmission belt 15 weighing device 16 console 17 fermentation box 18 air purifier Collection box 20 mixers 21 storage tank 22 oil and water separation tank 23 Filter 24 sewage purification tank

Figure 1: Overall design drawing of kitchen waste processor

## 2. Introduction to the overall composition and design of the small and medium-sized restaurant-kitchen-waste disposal machine

The kitchen waste disposal machine has the function of crushing type and biological bacteria fermentation type. The kitchen waste is crushed first, and then through solid-liquid separation, the solid residue is obtained. The solid residue is processed for biological bacteria fermentation. Its basic structure is composed of automatic feeding system, crushing system, solid-liquid separation system, oil-water separation system, weighing system, fermentation system, water circulation and filtration system, cleaning system, automatic control system, etc. The overall scheme design is shown in Figure 1.

## 3. Design and analysis of the screw extruder

The screw extruder is a key core component of the solid-liquid separation system in the above kitchen waste disposal machine [3]. Its design level directly determines the efficiency of solid-liquid separation of restaurant-kitchen waste crushing slurry and the service life of waste disposal machine. Based on the theoretical guidance of the basic mechanical principles, this study uses the analytical method of discrete element to design the simulation test, explore the influence of each parameter of the mechanism on the effect of extrusion dehydration, and find the optimal solution.

### 3.1 Design principle of the screw extruder

Screw extruder is mainly composed of feed inlet, screw, shell, outlet, conical extrusion block, pressure spring, belt drive system, motor, control system and other components. The overall structure is shown in Figure 2. The working principle is: kitchen waste enters the shell from the top inlet and moves forward along the groove under the rotation of the screw and fin. With the rotation of the screw and the gradual compression of the groove space, the material is subjected to extrusion, shear and friction forces, accumulated to the diameter near the outlet, and finally extruded from the outlet. The discharge port is the extrusion part of the whole device, because the plugging of the tapered extrusion block and the thrust action of the adjustable pressure spring can further increase the extrusion strength of the solid residue. Because the fin pitch changes from large to small, the compression ratio of the solid residue is further increased. The extruded liquid water oil mixture flows through the lower outlet. This completes the process of solid-liquid separation.

### 3.2 Design parameters of the screw extruder

Total length: 670mm; screw diameter: 38mm, thick diameter 67mm; pitch: 46mm, outlet about 24mm; shell diameter: 105mm; material: 304 stainless steel.

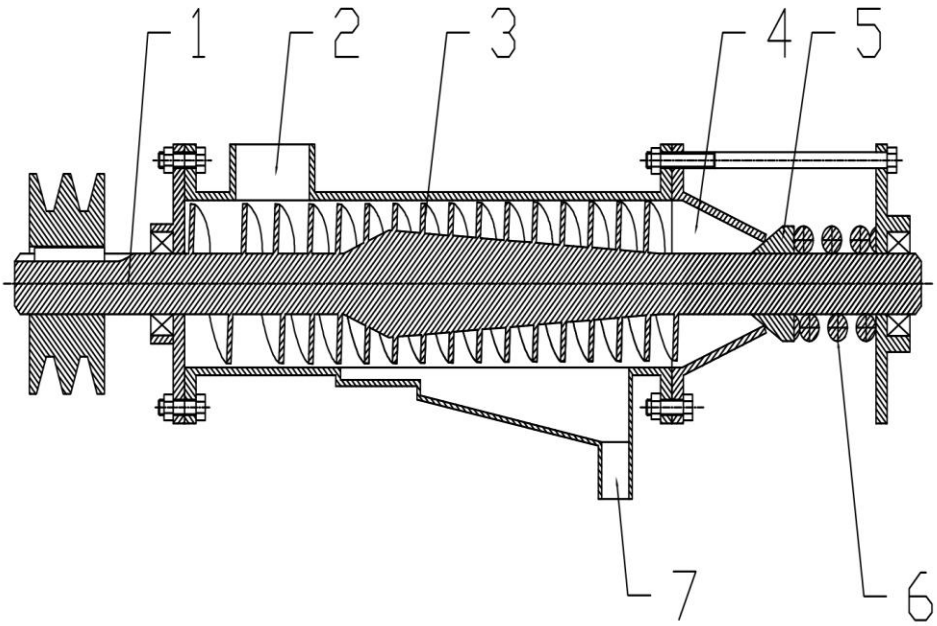
Screw structure design: The screw is designed to gradually reduce the pitch to achieve gradual compression.

Transmission mode: triangular belt drive driven by three-phase motor, so as to protect the motor when the extruder is blocked.

Shell design: the inlet is 75mm diameter for easy access of kitchen waste; the outlet is 52mm diameter and reduces the volume of solid residue and adjusts the compression ratio of output through the cone extrusion block and the pressure spring. At the same time, the shell outlet port is designed to be removable and easy to clean the function.

Filter device: mounted above the outlet and between the shell, using a stainless steel screen to filter the precipitated liquid to further separate the solid and liquid. The liquid is discharged through

the outlet and the connected catheter and goes into the oil-water separation tank for the next treatment [4].




1. Screw 2. inlet 3. rotating wing 4. outlet 5. Conical extrusion block 6. Pressure spring 7. The liquid outlet

Figure 2: Overall design of screw extruder

### 3.3 Experimental test and analysis of the screw extruder

After the prototype, the performance parameters are tested and the results are briefly analyzed. The material used is kitchen waste with water content of 70%; it mainly tests the influence of filling rate, screw speed and elevation angle of extruder on the extrusion effect.

The effect of the filling rate on the extrusion effect was tested first. Three different filling rates, 50%, 75% and 100%, analyzing the content of liquid and solid residue. The following conclusions are drawn: when the filling rate is 50%, the material is sparse, the extrusion pressure is insufficient, and the solid-liquid separation effect is poor; when the filling rate is 75%, the material density is moderate and the extrusion effect is good. The water content in solid residue is significantly reduced, and the solid-liquid separation effect is good; when the filling rate is 100%, the material density is large, the high material flow in the screw, and the load of the extruding machine is increased, and the operation is unstable. In conclusion, the optimal filling rate was 75%. At this filling rate, the extrusion function can achieve a more ideal solid-liquid separation effect, the solid residue water content is low, the machine operation is balanced, no overload.

Test the influence of the screw rotation speed on the extrusion effect. The goal is to find the optimal speed to achieve the most efficient solid-liquid separation. Three speeds of 50 rpm, 100 rpm and 150 rpm were set respectively to test the water content of solid slag at the outlet and evaluate the effect. The conclusion is as follows: the optimal rotation speed is 100rpm. At this speed, the screw extruder can achieve an ideal solid-liquid separation effect. The solid residue has low water content and high liquid purity. At the same time, the machine runs smoothly at this speed, which can avoid additional wear and energy consumption caused by high-speed rotation.

Test the effect of the mounting elevation angle on the extrusion effect. The aim is to find the best mounting elevation angle to achieve the most efficient solid-liquid separation. Set three installation

angles of 0°, 15° and 30° respectively to detect the water content of solid slag at the outlet and evaluate the effect. The conclusion is as follows: the best installation elevation angle is 15°. At this Angle, the screw extruder can achieve a more ideal solid-liquid separation effect, and the solid residue has low water content and high liquid purity. At the same time, the material liquidity is improved, and the retention time in the screw is moderate, which improves the treatment efficiency.

### 3.4 Summary

Through the experimental test, the filling rate and rotation speed affect the extrusion pressure, and the installation elevation angle is less. After the extrusion process stabilization, the extrusion occurs mainly in the squeezed and filled segments of the small pitch. The screw extruder has the best extrusion effect with 75% filling rate, 100 r/min rotating speed and 15° inclination.

## 4. Conclusion and outlook

According to the demand of small and medium-sized intelligent kitchen waste processor, the design points of screw extruder are analyzed, and the design scheme is verified through experiment. The results show that the reasonable design of screw extruder can effectively improve the treatment efficiency of kitchen waste and realize the goal of waste reduction, harmless and recycling. In the future, it can be improved from the following aspects: combining the Internet of Things and big data to realize remote monitoring and fault diagnosis of the operation status of the equipment, improve the intelligent structure of the equipment, optimize the processing efficiency and dehydration effect, reduce the energy consumption; optimize the design, improve the process, and adopt new materials. It is believed that with the continuous progress of technology and the accumulation of application experience, the intelligent kitchen waste processor will be more widely used, to make greater contribution to solving the problem of municipal waste.

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## References

*[1] Yao Liming, Wang Yazuo, Fan Honggang, Gu Jing, Yuan Haoran, Chen Yong. Progress of restaurant waste treatment and pyrolysis technology [J]. Chemical Progress, 2023, 42 (07): 3791-3801.*
*[2] Shi Dongchang, Tang Xiaoyan, Lu Changxin, Xu Gang, Lu Yanzhong, Lu Qing. Comparative study on the utilization of organic waste [J]. Environmental Health Engineering, 2022, 30 (05): 55-59.*
*[3] Wei Jiamiao, Zhang Xinyue, Peng Huanghu, Hou Yongchao, Han Zhicheng. Analysis of the variable pitch screw extrusion device based on SolidWorks [J]. Equipment Management and Maintenance, 2023, (06): 36-37.*
*[4] Feng Shuo, Wang Yangang, Wang Xinkun, Yuan Hao, Liu Wei, Guo Pengning. Study on the performance of food kitchen waste spiral extrusion device based on discrete element method [J]. Food & Machinery, 2022, 246(04): 109-113.*