Design of intelligent kitchen waste sorting machine based on Pro/E and Adams

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Abstract: In order to effectively solve the problem that the subsequent waste treatment is affected by foreign bodies such as bones and hard shells in kitchen waste, reduce the treatment cost and improve the utilization efficiency of kitchen waste, this paper designs a small kitchen waste Intelligent Classification Recycling and reprocessing device which can be applied to school canteens, communities and township waste treatment plants. The device is mainly composed of mechanical body, central processing unit, detection and sensing system and post-processing system design. It can further separate kitchen waste on the basis of solid-liquid separation, realize reprocessing and recycling, and maximize the recycling value of kitchen waste, so as to achieve the purpose of energy conservation, emission reduction and sustainable development.

1. Introduction

With the development of society and the substantial improvement of consumption level, the impact of improper treatment methods of kitchen waste on the environment and society is becoming more and more serious [1]. At present, the collection, transportation, supervision and treatment system of domestic kitchen waste is not perfect, a large number of kitchen waste directly enters the environment without treatment, or enters into the underground "black industrial chain" and is refined into "gutter oil", or into suburban livestock farms to feed livestock, in a short path into the human food chain, seriously endangering human food safety [2]. Therefore, the reasonable and efficient classification of kitchen waste plays an important role in the environmental protection of our country. However, at present, China's waste classification work has not yet been completed. Although cities at the prefecture level and above have started the domestic waste classification work, they have not built a unified domestic waste classification standard and treatment system. In daily life, people still habitually discard kitchen waste together with other domestic wastes, affecting the efficiency of kitchen waste treatment.

In this paper, a small intelligent classification machine for kitchen waste is designed by pro/e modeling and ADAMS simulation. First, the waste from kitchen is poured into the solid-liquid separation device for solid-liquid separation; then the separated solid is transported to the conveyor belt at a certain speed. The separated liquid flows out through the drain pipe connecting the box for water-oil separation and further treatment; under the action of negative-pressure motor, the solid moves forward through the conveyor belt; in the process of transmission, the high-definition camera is used to collect and process the image, identify the coordinates of kitchen waste to be sorted, and transmit the information to the central control system; finally, the stepper motor is controlled by the central control system, and the movement of the air pressure cylinder and the flip suction cup is controlled. The hard texture, hard shell and other foreign materials which are hard, not easy to break...
and limit the anaerobic fermentation speed are sorted out, while other kitchen waste is recycled and reprocessed. The scheme is suitable for community, garbage transfer station or waste treatment plant, and has a broad application prospect.

2. Design scheme

The intelligent kitchen waste sorting machine is composed of mechanical body (including solid-liquid separation device and sorting device), central processing unit, detection and the sensing system and the post-processing system. Its working diagram is shown in Figure 1. The machine body is equipped with a solid-liquid separation device, which can separate the liquid and residue by pouring the kitchen waste into the solid-liquid separation device. The separated liquid needs to be separated again from water and oil to produce biodiesel, while the residue needs to be separated. Part of the separated materials can be directly used for feed production, and the other part needs to be treated by anaerobic fermentation.

![Figure 1 Working diagram](image)

2.1. Overall structural design

The overall structure design and three-dimensional modeling of the machine are completed in Pro/E, as shown in Figure 2. After the kitchen waste passes through the filter device 11, the liquid is directly collected for refining biodiesel, and the solid part falls on the conveyor belt 5 under the action of gravity. The negative pressure motor 8 controls the transmission of the conveyor belt 5, the sensor 4 is equipped with a high-definition camera, and the stepper motor 1 controls the movement of the synchronous toothed belt and the transmission gear set, thus controlling the movement of the screw conveyor 9. The screw conveyor 9 is equipped with a discharge pipe, and the reversible suction cup 10 (Figure 3) is connected with the pneumatic cylinder 2, which can move left and right and turn 90 degrees-angle.

2.2. Central processing unit

The central processing unit is mainly composed of upper computers, MCU and sensor. The processor of the central processing unit is stm32f407 single MCU based on cortex M4 core of ST company. The main frequency of it can reach 168mhz, with high acquisition frequency and high-speed processing; At the same time, it has powerful peripherals, fast analog-to-digital conversion speed, low ADC / DAC working voltage, up to 32-bit timer, USART and SPI communication to meet the requirements of the system.

The moving part of the system includes stepping motor and pneumatic cylinder. Using six channels of tim8, STM32 advanced timer, output PWM and external drive circuit to control system movement.

The HD camera adopts openmv, a machine vision module with low power consumption and low cost. It uses official open source code for real-time image acquisition, large color blocks recognition and positioning. The schematic diagram of the control system is shown in Figure 4.
2.3. Detection and sensing system

The detection and sensing system are mainly composed of high-definition camera device openmv. Openmv is an open source, low cost and powerful machine vision module. Taking stm32f427 CPU as the core, ov7725 camera chip is integrated. On the small hardware module, the core of machine vision algorithm is implemented efficiently with C language, and python programming interface is provided. In addition, stm32f427 adopted by openmv has rich hardware resources, leading to UART, I2C, SPI, PWM, ADC, DAC and GPIO interfaces, which is convenient to expand peripheral functions. The USB interface is used to connect the integrated development environment of openmvide on the computer to assist in programming, debugging and firmware updating. TF card slot supports large capacity TF card, which can be used to store programs and save photos.
When the kitchen waste moves with the conveyor belt, the openmv on the rack will collect the image of waste, and use the color block area feature for image processing to determine the bones, hard shells and other foreign matters that are not easy to anaerobic fermentation; When the garbage arrives near vacuum suction cup, the suction cup will move to the place where the garbage passes through the automatic control system, and the garbage will be sucked by the negative pressure, and then the vacuum suction cup will translate and rotate upward by 90 degrees through the synchronous toothed belt. Release the negative pressure and put the garbage into the screw conveyor to complete the sorting.

2.4. Post processing system

Anaerobic fermentation is a new treatment method rising in recent years. The treatment process includes hydrolysis acidification, hydrogen production, acetic acid production and methane production. Anaerobic fermentation has significant advantages: high degree of harmlessness, and high organic compound bearing capacity; Organic matter is fully utilized, which is in line with the national energy policy while realizing the recycling of garbage; Maximize the recovery of oil in kitchen waste.

After separation, the kitchen residue generally needs to be treated by anaerobic fermentation. Under anaerobic conditions, a large amount of organic matter is decomposed to produce biogas, biogas residue, biogas slurry and other recyclable substances through the action of anaerobic microorganisms. Biogas can be used to produce natural gas and other fuels to provide heat and power for the normal operation of the system. The biogas residue and biogas slurry can be used to make fertilizer for farmland.
The sorted bones, hard shells and other foreign bodies can be used to make animal feed. The liquid after solid-liquid separation is treated by oil-water separation, and the separated oil is used to produce biodiesel.

3. Working principle
Firstly, the kitchen waste is poured into the solid-liquid separation device 11 (see Figure 2) containing the end opening of the filter screen, and the filter screen uses gravity to separate the kitchen waste from the solid-liquid; Under the action of vibration, by controlling the size of the discharge outlet, the separated solid is discharged to the conveyor belt 5 at a certain speed, and the separated liquid flows out through the drainage pipe connecting the box for water oil separation and further treatment; Under the action of the negative pressure motor 8, the solid moves forward through the conveyor belt 5; In the process of transmission, the sensor 4 collects and processes the image, identifies the coordinates of the kitchen waste to be sorted, and transmits the information to the central processing unit; The central processing unit controls the stepper motor 1 to make the pneumatic cylinder and the reversible suction cup work, put the garbage in the screw conveyor 9, and discharge it through the connected pipe for further treatment; Other wastes are collected for further treatment.

4. Dynamic Simulation
3D model of the structure is set up in Pro/e first. Next it is saved as *.x_t. Open the Adams software. In Adams, the *_x_t file is imported to be carried out the dynamic simulation of this model. Set the motion on Motor1 as 30d*time, time=5, steps=500. The simulation results are shown from Figure 5 to Figure 9. It shows that the structure is working as design, which fully verifies the feasibility of the design in theory.

![Image](figure6.png)  
**Figure 6**  when time = 1.0900s, the suction cup Moves to the top of the garbage

![Image](figure7.png)  
**Figure 7**  when time = 1.9100s, the suction cup moves downward
5. Conclusion

This paper establishes a simulation model for the sorting problem of kitchen waste, and makes the following improvements on the basis of the traditional classification device: smaller floor area and lower cost; the central control system is composed of single MCU, which is more convenient and faster to operate; the kitchen waste is treated by classification, and the recovery efficiency became higher; the centralized treatment of kitchen waste completely transforms kitchen waste into available resources, and realizes the harmless and resource utilization of kitchen waste, so as to turn waste into treasure and develop circular economy.

The intelligent kitchen waste sorting machine improves the treatment mode of kitchen waste, realizes the recycling of kitchen waste at low cost, and fully practices the concept of energy conservation and emission reduction. It has a wide application prospect under the background of high demand for sanitary treatment of kitchen waste.

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