DESIGN OF AN AUTOMATIC FOOD CLEANING MACHINE BASED ON SIMATIC LOGO

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ARTICLE DETAILS

ABSTRACT

This paper introduces the design method of a multifunctional automatic food cleaning machine based on SIMATIC LOGO!, which can be used to automatically clean fruits, vegetables, grains, meat and other foods by using the combination of the three cleaning methods, ultrasonic, ozone and air bubble. The process of development of the system illustrated through explaining the working principle, product appearance design, construction design, hardware and software design. A physical prototype has been developed according to the design method proposed, and the test verifies that it realizes the functions by the design purpose. It has the advantages of simple structure, easy operation, high automation, working reliably and efficiently, which helps to get rid of the traditional hand-washing pattern, and has wide application prospect and huge market demand.

1. INTRODUCTION

Cleaning the fruits, vegetables, grains, meat, etc., is an indispensable part in our daily life. Whether cleaning totally is directly related to the health of the human. Manual cleaning is not easy to clean pesticides and will make other harmful substances remain in the food, which cannot meet the needs of modern life [1]. In recent years, with the increasing improvement of people's living standards and the development of internal and external trade, there are more and more output of food processing. Manual cleaning not only takes a lot of time, effort and water, but also cannot meet the requirements of large-scale production of food processing, it is required to use mechanized cleaning to meet the needs of life and production. Fruit and vegetable cleaning technology in China started in the 1990s, over more than 20 years of development, there are some achievements. The cleaning method represented by automatic cleaning has caused extensive research. The vortex flow washing method is applied to a fruits and vegetables washer, research shows the washer has the features of high efficiency and energy saving [2]. A ultrasonic cleaner is designed for cleaning palette for painting, but its cleaning method is single [3]. The multifunctional ultrasonic-ozone washer was designed by the technologies of ultrasonic washing and ozone washing, which integrates the functions of decontaminating, sterilizing and reducing pesticide residues [4].

There are many kinds of fruits and vegetables, such as root vegetables of potato, sweet potato, taro, etc., with hard surface, fruits of apples, pomegranates, pears, etc., leafy vegetables with soft surface such as cabbage, mustard, etc., and the fruits of grapes, plum, etc. Root vegetables can bear greater pressure, leafy vegetables can bear less pressure. Different cleaning methods may be used for different kinds of food, cleaning machine is necessary to clean totally, and ensures the quality of cleaning. So, it is necessary to design a food automatic cleaning machine which is with large cleaning volume, can clean many kinds of food, with high cleaning rate, small damage rate and less water use.

In this paper, the multifunctional automatic food cleaning machine designed, SIMATIC LOGO! controller was taken as the core, it takes ultrasonic as the main cleaning power, through the ozone generator to realize food sterilization and disinfection functions. Its function keys are clear, it has the advantages of easy operation, powerful function, it is an necessary all powerful helper of home kitchen, restaurant and school canteen. This cleaning machine can not only improve the degree of automation, save labor force and let people get rid of the traditional hand cleaning mode, but also improve the cleaning quality of vegetables,

effectively remove the dirt, soil and dust, etc., on fruits and vegetables, reduce the damage to the food itself, clean totally, use less water, it will not cause secondary pollution to the environment.

2. DESIGN OF CONTROL METHOD

2.1 Cleaning Method

The cleaning methods of ultrasonic, ozone and bubble are described respectively below. As an advanced and efficient cleaning technology, ultrasonic cleaning has been widely used at home and abroad. In recent years, the number and types of ultrasonic cleaning machines increased dramatically due to more and more domestic manufacturers produce ultrasonic cleaning machines. The ultrasonic wave generator through cleaning machine trough wall radiates ultrasonic waves into the cleaning liquid in the trough, generating micro bubbles and keeping shaking, so the dirt adsorbed on the surface of the food will quickly fall off. It has the following advantages:

a) Ultrasonic cleaning speed is quick, efficiency is good. the parts with more complex shape and narrow gaps and holes can be cleaned by ultrasonic cleaning.

b) Ultrasonic cleaning can greatly improve the surface smooth of the cleaned parts, it plays an important role in the development of modern electronics, aviation and aerospace, etc.

c) Ultrasonic cleaning's easy processing and continuous automation of in the cleaning process can greatly reduce the labor intensity of cleaning.

Ozone is named for its unique odor, it is a strong gas oxidant, has the advantages of strong bactericidal power, no residual contamination production, directly being used for food, etc. As a broad-spectrum high-performance fungicide, its bactericidal speed is 300 to 600 times faster than chlorine, it can fast kill all kinds of bacteria, spores, viruses and fungi, such as E. coli, Salmonella, Staphylococcus aureus, Bacillus subtilis black Variant spores, Aspergillus niger, hepatitis B surface antigen, etc. Ozone is extremely unstable, it can be decomposed into oxygen by itself, does not produce any residue, the automatic cleaning machine designed in this paper will send the ozone produced by ozone generator to the cleaning trough, then ozone affect bacteria directly to damage its metabolism and breeding process, to achieve the function of sterilization [5].

Bubble cleaning mainly uses cavitation function. in the process of Bubbles

continue to go up, they will enlarge, when encountering the surface of fruits and vegetables, they will be broken, at that time, they will create high-speed micro-jet, which has a great pressure, then it can clear the pollutions on the surface of the food. At the same time, the disturbance function of airflow can also effectively remove the dust on the food surface.

2.2 Design of Operation Mode

There are five different operating modes for multifunctional automatic food washer. Each working mode corresponds to clean different kinds of food. The possible harmful substances in food and the time required for cleaning are shown in Table 1.

2.3 Design of Product Structure and Appearance

The appearance and internal structure of multifunctional automatic food cleaning machine are shown in Figure 1 and Figure 2 respectively.

Table 1: Cleaning mode

| Cleaning mode	Cleaning food	Harmful substance	Cleaning time
Mode 1	Pumpkin, tomatoes, onions, broccoli etc.	Pesticides, hormones preservatives	8 min
Mode 2	Fruits (apples, pears, oranges, grapes, strawberries, etc.)	Insecticides, preservatives,	6 min
Mode 3	Pork, beef, lamb etc.	Bacteria, parasites	10 min
Mode 4	Shellfish, shrimp, conch etc.	Bacteria, hormones	8 min
Mode 5	Rice, cereals etc.	Preservatives, insects	4 min
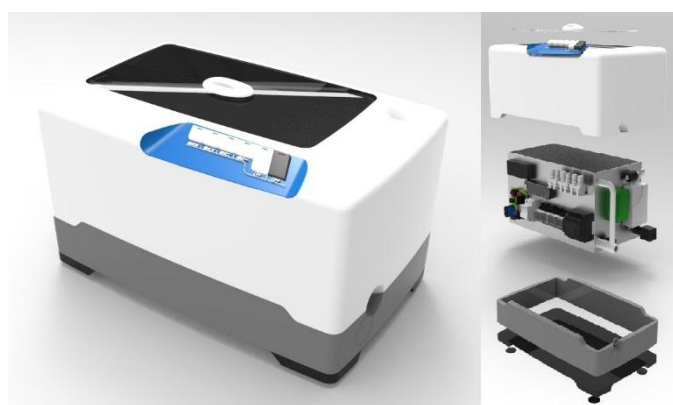
Figure 1: Appearance of product
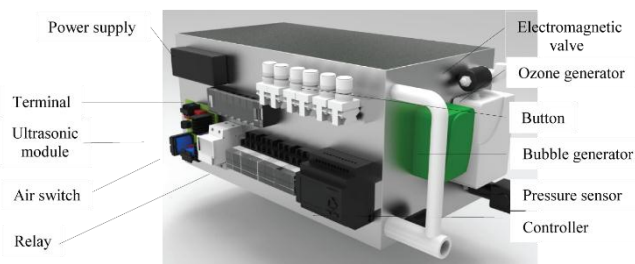
Figure 2: Internal structure of product

3. HARDWARE DESIGN

3.1 Hardware Selection

LOGO! is a micro programmable logic controller(PLC) developed by Siemens company, not only has the functions of count, timer, display, logic operation and parameter setting, but also has the ability of analog control [6]. It is an ideal upgrade product to replace the relays and other components in the power distribution cabinet.

Automatic food cleaning machine has 6 digital inputs, 1 analog input and 5 digital output, taking into account the need of timer function, LOGO! 12/24RC and digital expansion module DM16 are chosen. In addition to the LOGO! Controller, pressure sensors, ozone generators, bubble generators and ultrasonic generators and other equipment are also used in this design.

3.1.1 Pressure sensors

Pressure sensors are the most widely used type of sensor in the field of automatic control. The outputs of pressure sensors are generally analog signals. The commonly used pressure sensor is made by the principle of piezoelectric effect, so it is also called piezoelectric sensor [7]. The connection method of pressure sensor includes two wire system, three wire system, four wire system and five wire system [8]. The pressure sensor used in this design is a kind of diffusion silicon pressure transmitter. As the analog input of LOGO! is 0~10V, the four wire connection method is adopted. And because the height of the flume is about one meter, the measuring range is 10KPa.

3.1.2 Ultrasonic generator

Ultrasonic generator, also known as ultrasonic drive power, ultrasonic controller, electronic box, is an important part of the ultrasound system. Its main function is to convert the 220V electric energy into a high-frequency AC signal matching the transducer to drive the transducer. The main role of ultrasonic transducer is to convert the input electrical energy into acoustic energy (mechanical energy), and it consumes very little energy. Ultrasonic generator amplifier circuit is divided into two types: switching circuit and linear amplifier circuit. As the power conversion efficiency of the switching power supply is higher than that of the linear amplification circuit, the ultrasonic power generator with relatively large power generally adopts the circuit form of the switching power supply. Ultrasonic frequencies generally use 20KHz, 25KHz, 30KHz, 40KHz, 60KHz, 80KHz, 100KHz [9]. Power and frequency are 60W and 40KHz of the ultrasonic generator and transducer in this design.

3.1.3 Ozone generator

Ozone generator consists of ozone generator, driving circuit and air pump. This ozone generator uses a new type of creeping discharge ceramic electrodes as ozone generating devices. The corona discharge is driven by the high frequency and high voltage power supply to form the low temperature plasma, and the high concentration ozone gas is generated through the reaction of the oxygen on the surface of the high-efficient ceramic electrode. The installation, use and maintenance of the zone generator are convenient. As long as the power supply is connected, the high efficiency and stable ozone output can be provided. It can produce large amounts of ozone without residual toxic substances.

3.1.4 Bubble generator

Small bubble generator uses special synthetic rubber, which has constant pressure, stable performance and good safety. The two stage gas regulation can adjust the gas volume according to the usage, and the double bubble output can provide a large amount of bubble output.

3.2 I / O Address Assignment

The I/O address assignment of automatic food cleaning machine is shown in table 2.

Input	Address	Output	Address
Start mode 1	I1	Water pump	Q1
Start mode 2	I2	Ultrasonic device	Q2
Start mode 3	I3	Bubble generator	Q3
Start mode 4	I4	Ozone generator	Q4
Start mode 5	I5	Electromagnetic valve	Q5
Stop button	I6		
Pressure sensor	AI1		

4. SOFTWARE DESIGN

LOGO! Soft Comfort is an integrated programming and simulation software developed by SIEMENS company for LOGO! controller, by which the design is programmed and debugged [10]. The software flow chart of the automatic food cleaner system is shown in Figure 4. Press the start button, select the cleaning mode, and start water flooding. Check whether

the preset level is reached by the pressure transmitter, if not, continue to enter the water till it reaches the preset level, and the ultrasonic generator, ozone generator and air pump work simultaneously to clean the ingredients. When the set time is reached, the washing is stopped and the discharge of dirty water is performed. According to the current working mode, the water is discharged again to continue washing the ingredients. The machine stops working when it reaches the preset washing times.
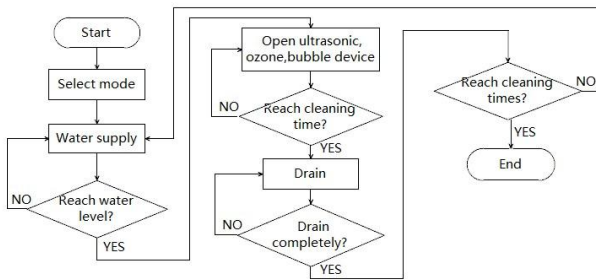

Figure 3: Program flow chart

5. EXPERIMENT

After the completion of hardware design and software debugging, the prototype of automatic food cleaning machine was manufactured, and the cleaning experiment was carried out. The experimental results show that the prototype achieves the designed functions, and its working performance is stable and reliable. Even without the use of cleaning agents, it also has a good cleaning effect, and dos not cause damage to the surface of the washed food.

6. CONCLUSION

The multifunctional automatic food cleaning machine designed in this paper takes the SIMATIC LOGO! as the control core, which is suitable for cleaning and sterilizing many kinds of food such as vegetables, fruits, grains and meat. Combining with ultrasonic, ozone and bubbles cleaning methods, the cleaning machine improves the washing effect obviously. A prototype construction and its test verify the reliability and effectiveness of the proposed method.

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