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An automatic dried shrimp peeling system

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Abstract

This study focuses on designing an automatic dried shrimp peeling system. The system has two operating modes: manual and automatic. The process is from feeding dried shrimp into the beating cage, peeling the shrimp and floor to remove broken shrimp shells from shrimp meat, and peeling dried shrimp shells to form a complete system. Construction system with automatic packaging and vacuum function. The solution is to use the Programmable Logic Controller (PLC) to communicate with the inverter to control the 3-phase motor to run at many speed levels to suit the peeling of different types of shrimp and the output of the system is dried shrimp packaged and vacuum sealed. The HMI control and monitoring unit will be applied to set parameters on the number of dried shrimps in each batch and the type of shrimp that needs to be evaluated and quantified in the package.

Keywords: Dried Shrimp; Peeling system; PLC; Shrimp packaged

1. Introduction

Tra Vinh province (Vietnam) has a shrimp farming area of over 25,000 hectares out of a total area of 37,500 hectares of aquaculture land in the coastal area of the province. To process and preserve typical aquatic resources such as dried shrimp, most people dry and peel the shrimp manually. For example, after the shrimp is dried, people will put them in woven Polypropylene bags and continue beating soil, and cement floor, until the shrimp shells are completely crushed, they will be stripped, sieved, and finally placed in glue or plastic bags for preservation. This manual method does not ensure food hygiene because during the beating process, it encounters the ground, and cement, and most of the Polypropylene woven bags used to beat dried shrimp are taken from used rice bags, and at the same time produce dried shrimp that is crushed and has no clean shell. Currently, in foreign provinces, there are dried shrimp peeling products and products that people make by hand using manual machines that do not ensure hygiene and safety. Looking up the dried shrimp peeling machine, Tech Garden Company has produced a dried shrimp peeling machine using compressed air, but the product only serves one specific step: shrimp shelling, sieving, or packaging. Each machine is not linked together, so a lot of human resources are needed for each stage. However, in Tra Vinh province, no similar research projects have been found. Therefore, to ensure food safety and quality, dried shrimp can be preserved for longer than 6 - 12 months, saving time, and manpower and at the same time providing necessary treatment at the right time. Therefore, the idea of designing and manufacturing an automatic dried shrimp peeling system with adjacent connected structures, from the shrimp tank to the shrimp shelling mechanism, sieving structure and finally the automatic packaging structure, the user can adjust the time of the entire shrimp shelling process: shrimp shelling time, sieving time, and packaging quantity through the HMI screen. In addition, the system is also designed to retain crushed shrimp shells for recycling to protect the environment.

In this study, a PLC system [2] is programmed to communicate with an inverter to control a 3-phase motor running at many speed levels to suit the peeling of different types of shrimp, and the output of the system is shrimp. dry, packaged, and vacuum sealed. The HMI control and monitoring unit will be applied to set parameters on the number of dried

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shrimps in each batch and the type of shrimp that needs to be evaluated and quantified in the package. In addition, the HMI is also used to operate the MAN mode (manual mode) of the system.

The main contributions of this study are:

- Design a system for separating dried shrimp and preserving dried shrimp.
- Design a vacuum system to ensure food safety and hygiene.
- Run tests and produce satisfactory results to increase productivity.

2. Material and methods

2.1. Description of the equipment

In this section, details of the device components will be presented. The FX-5U PLC controller is the first model in the iQ-F series, the FX-5U, providing high performance in a compact, cost-effective package. The FX-5U inherits the FX series' previous advantages of complete flexibility by offering a range of new and existing add-on options that further enhance the built-in functions of Ethernet, I/O analog, data logging, location control, security, communications, and networking functions are integrated as standard.

HMI (Human Machine Interface) screens are widely used in industry, as devices that allow operators to control and monitor the operating mechanisms of machines. In other words, the HMI screen has two main functions: control and monitoring of the actuator. The HMI screen used in the design is Mitsubishi's GS2107-WTBD HMI screen from Mitsubishi [3]. Mitsubishi GS2107-WTBD HMI screen design and programming software is GT Designer3.

Figure 1 The main equipment used in the system: PLC FX5U-64MT/ES, HMI GS2107-WTBD and FR-E800 inverter

The FR-E800 inverter [4] is an upgraded line of the previously quite successful FR-E700 inverter. It is designed to meet the strict drive control requirements in many different automation systems such as packaging systems, material handling systems, and production lines in food factories and factories. water treatment machines, industrial plants... The FR-E800 inverter has built-in popular industrial communication protocols such as CC-Link IE Field Network Basic [5], Profinet [6], Ethernet/IP [7], Modbus TCP/IP [8], and BACnet [9]. Besides, the 2 included Ethernet ports make it easy to connect with connection circuit types such as line, ring, and star.

2.2. Connection system

The connection diagram of the devices and components of the system is shown in Figure 2. The specific operating process of the system is as follows:

- When starting to operate the system, turn on the power and press the reset button to start a new process. Then, set parameters for the feeding tray, and dosing tray and select the beating speed. Next, dried shrimp are put into the feeding tray. When completing the installation steps, press START for the system to start working. The feeding tray is raised to the working position, the shrimp cage rotates to the shrimp receiving position.
- After the correct amount of dried shrimp is put into the cage, the beating cage begins to operate. At the end of the shelling process, the dried shrimp is put down to a vibrating screen to remove the shrimp shell and the whole shrimp will go down to the dosing tray. After 3 times of shelling the shrimp, the packaging cycle is activated. The pneumatic cylinder system works to take the vacuum bag and open the mouth of the bag, then the dosing tray pours the shrimp according to the installed number of cans.

- After completing the clamping cylinder, proceed to the wrapping clamp and put it into the vacuum mechanism to proceed with packaging and sealing the bag. Finally, the conveyor belt runs to bring the finished product out.

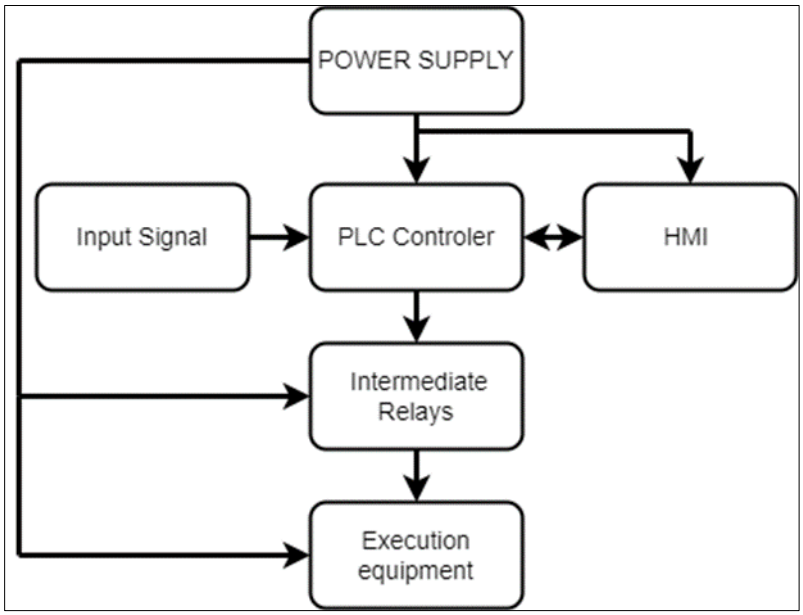

Figure 2 Connection diagram of components in the system

2.3. System operating procedures

The operating process of the system is shown in the flow chart in Figure 3. The system includes 02 operating modes: manual mode and automatic mode.

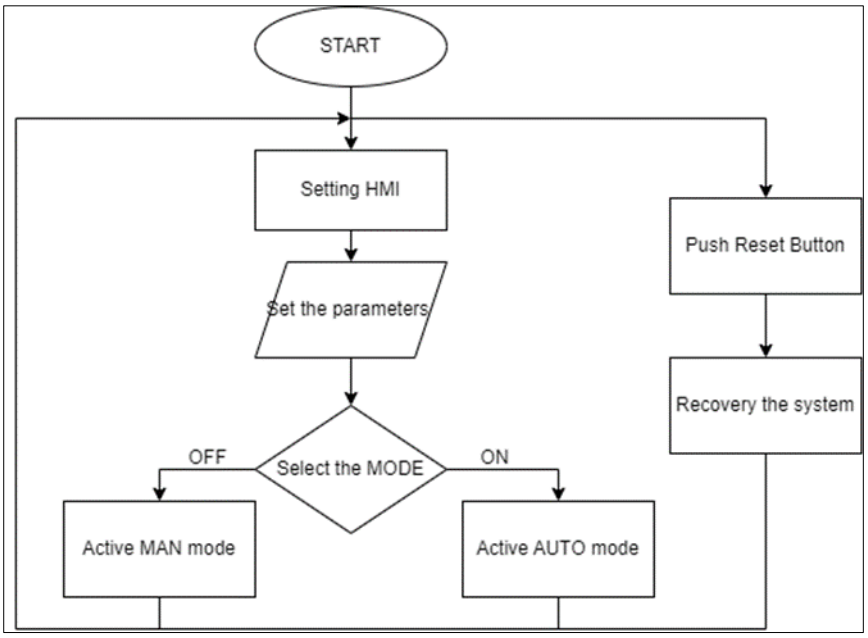

Figure 3 The flow chart of the system

When starting the program, parameters are set through the HMI screen. Check the switch to select the working mode. If the switch is in the ON state, the machine will work in MAN mode. On the contrary, if the switch is in the OFF state, the machine will work in AUTO mode. Check the status of the Reset button. If it is ON, the machine will restore its original state.

All operations of MAN mode are controlled through buttons designed on the HMI screen and show in the flow chart in Figure 4.

- Check the status of the feeding tray rotation button. If it is in the ON state, the feeding tray will operate and will stop working when in the OFF state. Check the status of the button to open the lid of the beating cage, the lid will open if in the ON state and close if in the OFF state. Check the feed tray lift button, in the ON state the tray will be raised. In case the tray raising, push-button is in the OFF state, the feeding tray lowering push button will continue to be checked. If it is in the ON state, the feeding tray will be lowered.
- When the Home button is ON, the drum will return to the HOME position in a counterclockwise direction. When the sensor confirms that it has returned to Home and a signal is sent to the PLC, the cage will stop and set that position as the HOME position.
- Check the cage rotation push button. If the push button is in the ON state, the shrimp-catching motor will run at the preset speed. The operating speed value of the motor is displayed on the HMI for users to see. monitoring operation. The motor will stop when the push button state is OFF.
- When the cage rotation button is in the ON state, the program will continue to check the signal of the reversing leg. If the signal is high, the cage will rotate in the positive direction and if the signal is low, the cage will rotate in the positive direction.

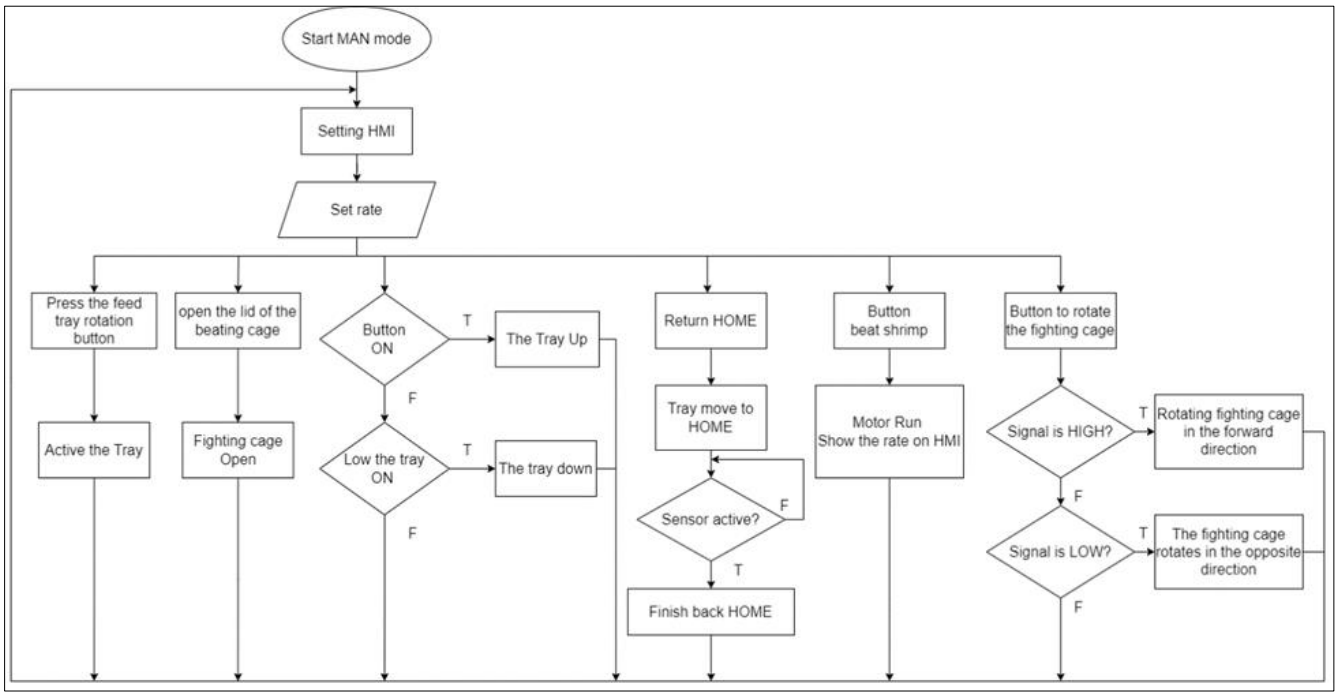

Figure 4 Flow chart of MAN mode

In the AUTO mode, the Start button will be checked, if it is in the ON state, the operating procedure begins. Figure 5 shows the flow chart of the AUTO mode.

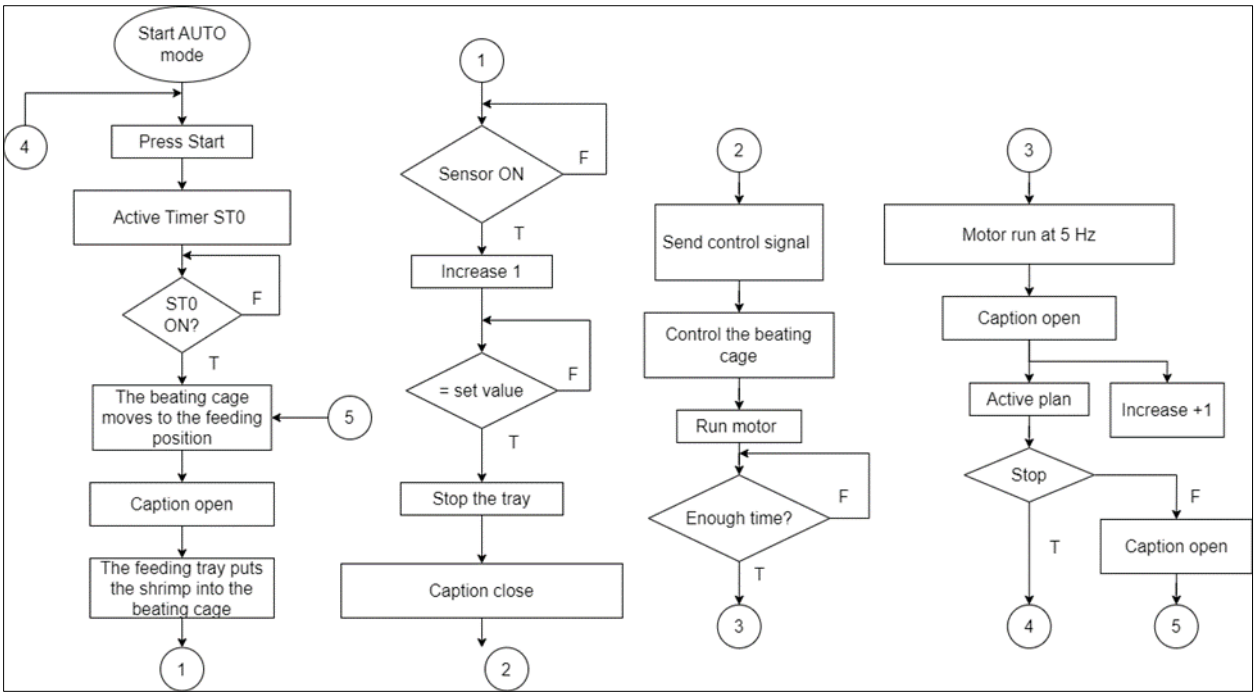

Figure 5 Flow chart of AUTO mode

- Firstly, the feed tray will be lifted and Timer latch ST0 will be activated to measure the lifting time. After the time to lift the tray ends, the ST0 ON flag turns up to control the beating cage to the feeding position, the lid of the beating cage opens, and the feeding tray begins to put dried shrimp into the beating cage.
- The can counting sensor starts working, each time the sensor changes the number of cans it will add 1. When counting the installed number of cans, the feeding tray stops, the beating drum rotates to the working position, and the lid of the beating cage is closed. At the same time, the PLC sends direction and speed signals to the inverter, from there the inverter controls the rotating motor.
- After enough shelling time has been set for each type of shrimp, the motor will rotate at a speed of 5Hz and move to the shrimp dumping position. The hitting cage lid opens, and the vibrating floor is activated. The variable number of shrimping times is added by 1.
- Next, the program to check the Stop button. If it is in the OFF state, the drum closes the lid and returns to the feeding position to start a new working cycle. If the Stop button is in the ON state, the machine will stop operating.

3. Results and discussions

The results of the system operation were carried out on 03 different types of shrimp: white-legged shrimp, black tiger shrimp and ground shrimp. Results of evaluating shrimp beating speed and time to complete a batch of dried shrimp. Detailed results are shown in Table 1.

Table 1 The experimental results

Type of Shrimp	**Ground Shrimp**		**White-legged Shrimp**		**Black tiger shrimp**	
	20Hz	**15Hz**	**20Hz**	**15Hz**	**20Hz**	**15Hz**
The Shrimp shelling time (second)	30	60	60	90	60	90
	60	90	90	120	90	120
	90	120	120	150	120	150
The results	Good at 15 Hz, 90 second		Good at 15 Hz, 120 second		Good at 15 Hz, 120 second	

With the results shown in Table 1, beating shrimp is best done at a speed of 15 Hz, and depending on the type of shrimp, there will be a corresponding beating time. Specifically, it takes 90 seconds for ground shrimp to achieve good quality, 120 seconds, and 150 seconds for white shrimp and black tiger shrimp.

Results of packaging experiments, the system was tested with 2 functions: automatic and manual. The results were that dried shrimp were put in bags and sealed by vacuum, achieving 97% results over 30 tests. The result was that 3% of the products were not finished because the bag was placed in the wrong position. Carry out actual packaging and evaluate the results when a good, finished product is produced.

4. Conclusion

In this study, a system for separating dried shrimp is introduced. By combining the basic functions on a shrimp peeling system into a complete system, it helps perform the process more quickly and accurately. Hardware systems are tested and evaluated to help make accurate decisions for the automatic system of separating dried shrimp shells. This is a complete system of stages from data entry to product packaging.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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