Development of Robotic Coordinated Control System for Bowl Food Packaging

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Abstract. The processing of the bowled food is relatively mechanical, repetitive and cumbersome, resulting in high work intensity, low efficiency, and high defect rate, and meets the working cycle:13.5s, positioning accuracy: 2mm. A PLC-based automatic feeding control system for food packaging line was designed. Including the conveyor line for bowl feeding, the numerical controlled manipulator and package process following control system for reclaiming and discharging functions, the system control scheme was proposed and 3D modeling construction was carried out. The design of hardware and software for feeding, reclaiming and discharging in the system is elaborated in detail. Finally, through the actual on-site commissioning and production operation, it is proved that the equipment has fully met the design requirements and greatly improved the production efficiency.

1. Introduction
In modern society, with the prosperous development of the economic level. In the high-tempo and high-intensity work life, we must not only emphasize the urgency of time, but also try to achieve a quality lifestyle in the intense working hours. And the state, fast food more and more appear in people's daily life, which has great requirements for the production efficiency of food processing[1]. Take the bowled food as an example; the processing flow of a finished product is basically divided into the following processes: Bowling, discharging, tamping, packaging, packing, and storage. There is an important link between the two processes of compaction and encapsulation, that is, the transfer of products from the bowl truck to the packaging line; the existing transfer mode of the enterprise is manual loading. This method is not only labor intensive, but also inefficient, easy to turn over the bowl [2].

2. Overall design
The main task of this design is based on the actual working conditions of the enterprise, and the problems of low efficiency, high strength and easy to turn over the bowl in the working process are the research background. The vacuum packaging line is analyzed under the premise of a certain working period, the manipulator and the vacuum packaging line. The cycle matching problem, according to the scheme for 3D modeling, and based on PLC, touch screen and configuration software to develop and design automatic feeding control system, its main design content: 1. bowl reserve convey or line system; 2. manipulator follower control system.
2.1. Bowl reserve conveyor line system
The preparation conveying line system comprises two parts: a guiding device and a separating device. The guiding device has the function of bowl guiding to avoid the occurrence of blocking during the feeding process, and the separating device has the function of bowl blocking, and the sensor detects the conveyor belt[3]. Whether the bowl is in place and the signal is transmitted to the steering gear in the separating device, the moving piece is driven to act as a bowl to meet the working requirements of the single grab of the manipulator, and the bowl conveying task of the conveyor belt is completed. Design and process the guide bowl conveying board and the spacer class, map and design the structure and the installation position of each part of the sensor to ensure that the signal can be transmitted to the controller in real time under the premise of accurate operation. Under the control of the system, the accurate work of the partition plate part is completed, and the gripper can accurately complete the gripping action when the bowl reaches the position to be grasped[4].

During the process of conveying the bowl, the detecting sensor detects that the bowl reaches the position to be grasped, the manipulator moves to grasp, and places the packaging line station; when
the detecting sensor and the blocking sensor simultaneously detect the bowl, at this time on the conveyor belt. Too much bowl, in order to prevent the accumulation and dumping of bowls during the transfer process, the conveyor belt stops. When the manipulator grabs and transfers the bowl, the conveyor belt continues to run, and the bowl is transferred to the position to be grabbed; the servo sensor detects the bowl entering. When the position working area is to be grabbed, the signal is sent to the steering gear. At this time, the steering gear drives the movement to block the incoming bowl[5]. When the manipulator grabs and transfers the bowl, the movement moves and the bowl continues to be driven to the position to be grasped.

2.2. Manipulator follow control system
The manipulator follows the control system with the process flow as the main line. According to different occasions, it is divided into manual and automatic modes. On this basis, the control circuit is designed, PLC is used as the core controller and the program is developed[6]. The interface of the manipulator's touch screen is designed and the prototype of the manipulator is applied. In the process of clamping and handling, the manipulator is required to move in the positive and negative directions of the X-axis and the positive and negative directions of the Z-axis. Two linear motion units are selected to realize the X-axis and Z-axis movement of the manipulator respectively[7].

- Since the object to be gripped is a plastic bowl of food, the clamped place cannot leave traces, so there is a high requirement for the strength of the gripping. Electric claw with self-adaptive force. The working state of the jaws is: initial state: N0.0 speed 300mm/s, the jaws are opened to 30mm on both sides, the jaws are in the initial state after resetting or system power-on; the state to be grasped: NO.1 speed 300mm /s, both sides of the jaws open to 22mm, waiting for the bowl to reach the specified position to be grabbed; grab state: NO.2 speed 300mm / s, both sides of the jaws contracted to 14mm, the strength is 30%, the bowl is detected When the position to be grasped is reached, the manipulator performs the grasping. When the force reaches 30%, the manipulator lifts up to perform the next placing action.

| NO | Move  | Speed/(mm/s) | Position/mm | Pushing/% |
|----|-------|--------------|-------------|----------|
| 0  | Absolute | 300          | 30          | 30       |
| 1  | Absolute | 300          | 22          | 30       |
| 2  | Absolute | 300          | 14          | 30       |

- According to the functional requirements and movement rules of the manipulator, the hardware of the control system is designed, and the PLC controller is programmed in software. The programming of the manipulator is a modular program editing idea[8]. The control system is divided into five parts: system initialization, system parameter setting, working mode selection, linkage operation and error clearing. Before the manipulator is fully automatic linkage operation, the Z axis, the X axis and the electric clamping jaw are reset, and the X axis and the Z axis are linked to each station in the manner of debugging operation, and the position parameter information of the station is obtained. The parameters are written to the PLC program[9].
3. Conclusion

According to the requirements of the enterprise, a set of mechanical equipment and control system with automatic feeding function was developed, which realized the precise control of automatic feeding of bowled food. 1. Due to the need to locate and grab during the feeding process, a mechanical device that can guide and separate bowls is designed to facilitate the grasping of the manipulator; 2. Since the object to be grabbed is a plastic bowl, the force is too large to be deformed, and the force is too small to grasp firmly, so the force feedback manipulator is used for grasping; 3. Select the cantilever type gantry manipulator to carry out the work, and place the bowl accurately at the station to achieve precise position control; 4. The package line is stepped once, and the manipulator works for one cycle to achieve follow control. The whole process is set by the PLC system, and the touch screen is used as the human-computer interaction window, which facilitates data input adjustment and reading, and realizes humanized operation. Improve the efficiency of the production line, reduce the labor force, meet the production cycle, and provide a theoretical basis for the later equipment improvement, with high economic value and engineering significance.

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