Control Analysis Based on the Operation of Automatic Captive Cleaning Equipment

Yunxian Weng*, Yaping Zhao and Juncheng Shi
Suzhou Polytechnic Institute of Agriculture, Suzhou, Jiangsu 215008, China

*Corresponding author: weng_yx@szai.com

Abstract. The project in this paper is a "district twinning" project of Suzhou polytechnic institute of Agriculture. In the paper, the author analyzes the sheds of pig cleanup job needs for farm in Yuping Mountain Ecological Park in Suzhou, and designs a new cleaning device and its appropriate electrical control systems without changing the traditional captive facilities. The paper first analyzes the Control Analysis Based on the Operation of Automatic Captive Cleaning Equipment.

Finally, the actual installation and debugging is explained, a brief description of several common problems, solutions and matters needing attention are given. The practice proves that the whole electrical control system is practical and reliable, and the desired effect is achieved.

1. Introduction
Although factory farming has the characteristics of intensive and large-scale, traditional small-scale free-range farming is still an important part of the current farming industry. Compared with the development of feed supply, livestock sales, epidemic prevention and health care, the breeding facilities are still basically stuck in the traditional mode, with high labor intensity, low breeding efficiency and difficult to expand the scale of breeding. Compared with the degree of automation of factory farming, small and medium-sized captive farming is still a blind spot of the current automation equipment.

According to the college-district pairing technical service project agreement signed by Suzhou Agricultural Vocational and Technical College and Suzhou Jade pingshan Ecological Park Co., Ltd., a technical service team consisting of 5 teachers and 3 students has been working in the No. 2 enclosure of Jade pingshan Pig farm since 2011 to automate the transformation of traditional enclosure facilities. After nearly two years of improvement and debugging, automatic control of daily feeding operations has been initially realized, including automatic feeding, automatic cleaning of pig manure, and regular and fixed point loading, unloading and cleaning of pig manure.

As members of the team of students, I participate the project, familiar with the electrical control system design, installation, debugging, now for this project cleaning mechanism of electric control system, and summarizes the research as my thesis topic selection, further optimize, improve my professional knowledge and skills of comprehensive application ability.

2. Control requirements for cleaning equipment operation
As shown in Figure 1, the layout of No.2 enclosure of the pig farm in Jade pingshan Ecological Park is a typical traditional layout of small and medium-sized scale, with a middle aisle and 7 pigsties on both sides. A single sty is about 4 meters in length, 3 meters in width and 1.2 meters in height.
After simple breeding, the captive pigs are known to defecate at a fixed point from a young age, and the feeding and rest areas in the front and the excretion areas in the back are naturally formed in the pens.

The traditional artificial feed operation is to feed twice in the morning and evening, and clean up the tail pig waste of the accumulation circle irregularly. During the operation, the breeder enters and leaves each circle successively, and finishes the feeding cleaning according to the number of pigs in each circle. The pig farm requested that regular and fixed feeding and cleaning operations be realized without changing the existing enclosure facilities during the renovation.

![Figure 1. Schematic diagram of traditional enclosure pattern.](image)

2.1. Operation tasks of cleaning equipment

According to the operation needs and the existing conditions of the enclosure, the overall scheme schematic diagram given by the project team is shown in Figure 2. Above the feeding area and the discharge area, relying on the triangular span beam on the roof, the Angle iron of national standard 50×50 is fixed as the suspension track respectively, and the monorail suspension and moving mechanism suitable for the Angle iron is designed. The specific feeding mechanism and cleaning mechanism are installed on the moving mechanism respectively. Under the traction of the driving cable, it can slide stably in each circle to realize the fixed time operation.

![Figure 2. Schematic diagram of the overall scheme.](image)

As for the operation tasks of the cleaning mechanism, it can successively identify the entry position of each circle, put down the cleaning hopper and slide along the track. After cleaning up the pig manure
in the entire discharge area, it reaches the exit position, lifts the cleaning hopper to above the height of the ring wall, and then sends it to the designated place to dump pig manure, so as to complete the cleaning work of a pigpen. Then identify the next pen that needs to be cleaned and complete the whole action in turn. The cleaning task will not be completed until all the pens to be cleaned have been cleaned once. The following focuses on cleaning operations, analyzing the composition and working principle of cleaning mechanism.

Manual control is mainly used for debugging before system operation, resetting and running to the initial position after fault alarm, and automatic cleaning of dead zone auxiliary operations. In the four movements of the mechanism, the running time of up and down is short, and the limit position of the mechanism is limited, so protection should be considered. Forward and backward actions take a long time to run, and through multiple sensors, suitable for manual visual control, should not be set protection conditions. For specific procedures, compared with automatic, manual control is easy to achieve.

2.2. Working principle of cleaning mechanism

The composition of the cleaning mechanism is shown in Figure 3, which is mainly composed of Angle iron guide rail, suspension frame, Cross Cheng, cleaning bucket, sprocket and slider guide bar, etc. The whole mechanism has the advantages of stable structure, low cost and easy to realize reliable control.

![Composition diagram of cleaning mechanism](image)

1 - framework; 2, guide rail; 3 -- auxiliary groove wheel; 4 -- brake disc; 5 - chain wheel; 6 - winding grooved wheel; 7 - slide block; 8 - cleaning bucket; 9 - the chain; 10 -- Cross Cheng; 11 -- Guide wheel; 12 - the guide bar

**Figure 3.** Composition diagram of cleaning mechanism.

The middle of the suspension mobile frame is provided with a coaxial winding groove wheel, a brake wheel, two symmetrically installed sprockets, and two auxiliary groove wheels are provided at both ends of the front and rear. The traction cable is cyclically wound on the winding grooved wheel and the auxiliary grooved wheel. Enough friction can be generated between the cable and the winding grooved wheel. When the traction cable is under stress within the allowable range, the grooved wheel and the cable will not slide relative to each other. The suspension frame and the Angle iron and the brake wheel
are separated and fixed by a group of electromagnet devices. When the suspension frame is separated from the Angle iron, and the brake wheel is fixed, the traction cable can pull the mechanism along the Angle iron slide; When the suspension frame is fixed between the Angle iron and the brake wheel is separated from the brake wheel, the traction cable enables the brake wheel and its coaxial sprocket to rotate. The diameter of the brake disc is 50 centimeters, the inner diameter of the winding grooved wheel is 10 centimeters, and the diameter of the chain wheel's indexing circle is 6 centimeters.

Suspension frame and the cleaning bucket is connected by two symmetrically distributed chain, one end of the chain is connected to the front of the cleaning bucket, the other end of the chain is connected to the rear of the cleaning bucket after winding the sprocket; There is a cross Cheng between the suspension frame and the rear part of the bucket. One side of the cross Cheng is hinged on the suspension frame and the other side is hinged on the slider attached to the guide bar. The hinged point on the rear side of the bucket is on the same straight line, along which the rear upper border of the bucket can only move up and down.

2.3. Control requirements for cleaning equipment
According to the operation requirements of the system scheme and combined with the working principle of the captive automatic cleaning equipment, the actual control requirements can be obtained as follows:

(1) The suspension frame can realize forward and backward in the specified place, and realize the return of each enclosure at the specified position.

(2) The cleaning bucket completes four steps in sequence: forward, downward, upward and backward, and completes the specified action transformation at the specified point to realize the cleaning, transportation and dumping of pig manure in a single circle.

(3) It can realize manual and automatic job switching.

(4) According to the actual feeding situation of each pigsty, the cleaning mechanism can complete the cleaning operation at a fixed time, time and circle by setting.

(5) the system should have protection function, once there are abnormal conditions, mainly cleaning bucket resistance is too large mechanism overload, unexpected power failure, etc., the system can stop alarm, manual reset.

3. Installation and commissioning of electrical system
In the actual installation, the frequency converter and contactor in the figure are driven by feeding and mixing equipment, which is not within the scope of discussion in this paper. The drive of electromagnet and motor can be directly drawn from the contact circuit of high-power relay.

In the debugging, the electromagnet does not pull, and there is no positive and negative requirement for the electromagnet in the DC circuit. The main reason for checking is that the clearance of the electromagnet from the Angle iron or the brake wheel is too large, or even because of negligence, the electromagnet is put in the sleeve in reverse, so that after electrification, it is adsorbed at the bottom of the sleeve. After adjustment, the practical application effect is very good.

JS30-D15NK proximity switch is shown in Figure4. Single-phase AC motor wiring has positive and reverse lines and common lines, and the parallel start capacitor between positive and negative turns. The wiring needs to distinguish the lead lines, and the wrong connection is strictly prohibited.

Figure 4. JS30-D15NK proximity switch.
Sensors installed on the hanging rack, electromagnet need along with the institutions run along a guide rail, its signal and drive wire banding beam are good, every 50 centimeters to plunge into a ring, ring to wear on the fixed on both ends of the wire rope, the formation of drag chain, drag chain should not interfere with slide rack, steel wire rope and the Angle iron rail distance outside the 0.5 meters is better.

The clamping ammeter is used to detect the starting current of the motor, the input current of the switching power supply and the electromagnet current are all qualified.

In actual debugging, the hand automatic switch is set in manual mode, and the electric remote control is used to test up, down, forward and back. The corresponding sensor signal is good or bad, and the reason for not triggering is basically how big the gap between the sensor and the protruding iron rod is. After adjusting the position, it can switch to the automatic state. The program is correct and the control effect is better.

Finally test the overload situation, after the protection time exceeds, the motor can automatically cut off the power supply. At the same time, in the case of unexpected power failure, the deceleration motor can self-lock, the cable is fixed, the test maximum load of 15Kg cleaning bucket can be suspended in the air; The load in actual operation is less than 15Kg, and the expected effect can also be achieved in the power off state during trial operation.

For the safety operation of the protection mechanism, the sensor detection position of each circle has a certain protection distance from the left and right ring walls. As a result, both sides of the ring wall cannot be cleaned automatically, and there is certain automatic cleaning dead zone. This can be effectively cleared by switching to the manual state at the worker's discretion. In addition, the occasional excrement outside the discharge area, a long handle push shovel made by local workers, standing outside the circle to push it to the discharge area, the cleaning equipment will automatically remove.

The automatic cleaning rate of the equipment is high, with manual control, can completely achieve no residual dung. Three times a day automatic cleaning, greatly reduce the labor intensity of workers, replace the original manual operation of dirty, tired, bitter, at the same time the circle of environmental health is also significantly improved. After the transformation, the workload of daily feeding manual is greatly reduced, and only one person is needed to inspect the feeding material, saving 2 labor.

4. Conclusions
This paper mainly states the control analysis based on the operation of automatic captive cleaning equipment. In recent years, with the improvement of automation technology, the realization cost of automatic control is also constantly reduced, and it has become possible to develop low-cost small-scale automatic breeding equipment. On the basis of all kinds of existing artificial breeding facilities in rural areas, if the low-cost automation transformation can be completely or partially realized, the labor intensity can be significantly reduced and the breeding efficiency can be improved, which has a certain practical significance.

Acknowledgments
This work was financially supported by Suzhou Polytechnic Institute of Agriculture Youth Promotion Project (PPN201412) fund.

References
[1] Jie Tao, Zhongming Shi, Fan Wu. Design and implementation of a low-cost ecological pig pen automation facility. Agricultural machinery, 2009,23:80-82, in Chinese.
[2] Hongfeng Liang. Study on technology of automatic collecting device for sheep shed manure. Decision and information, 2015, 8:266-267, in Chinese.
[3] Yuan Xu. Centralized pig farm pressure film reinforced cement dung leakage board production. Hubei Agricultural Mechanization, 2020,16:103-104, in Chinese.
[4] Ming Yi. Training skills of draft cattle. Farmer science and technology, 2006,2:26-27, in Chinese.
[5] Hequn Lu, Jing Gao. Training skills of draft cattle. Farmers are rich friends, 2006,1:7-8, in
Chinese.

[6]  Dejun Zhang, Yuelin Zhang. Why can't bean curd dregs feed milk directly. Aquaculture technical consultant, 2007,7:116-117, in Chinese.

[7]  Kainian Li, Deshan Lu. Why intensive farming methods are questioned. Animal Health in China, 2008,8:15-21, in Chinese.

[8]  China Agricultural University. Agricultural mechanics. China Agriculture Press, 1996,8:15-21, in Chinese.

[9]  Zhichao Xu. Production technology and utilization effect of factory pig farm in north cold area. Heilongjiang Animal Husbandry and Veterinary, 1998,6:22-23, in Chinese.

[10] Liming Song. The design and application of traditional piggery reconstruction technology and new environmental control piggery. Modern animal and poultry farming, 2017,7:50-51, in Chinese.