A new type of fruit and vegetable preservation equipment based on PLC control

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Abstract. In this paper, a new air conditioning and fresh-keeping control system is designed and studied, PLC technology, frequency conversion technology, sensor technology, parameter self-tuning PID technology and configuration monitoring technology affecting the fresh-keeping of environmental factors such as temperature, gas composition, humidity intelligent, energy-saving control and dynamic monitoring, ultimately achieve prolong time for fruits and vegetables, reduce the loss of the fruits and vegetables preservation equipment operation and energy saving purpose.

1. Introduction

The storage period of fresh fruits and vegetables can be prolonged by scientific and reasonable storage and preservation technology. Real-time monitoring, energy-saving operation, reduction of consumption in storage, adjust the low season and high season, promotion of fruit and vegetable industry development, with significant economic and social benefits, By cooperating with a local company, a kind of energy-saving vegetable and fruit preservation equipment was developed, realized the real-time monitoring of fruits and vegetables such as cherry, ginger, garlic and garlic, etc.

2. Theoretical Foundation

The most commonly used method of fruit and vegetable preservation is air conditioning storehouse. It is on the basis of cold air storage, increase gas composition adjustment function, by adjusting the temperature, oxygen concentration, carbon dioxide concentration, ethylene concentration, humidity and other factors in the storage environment, the respiration of fruits and vegetables can be inhibited, their metabolism can be slowed down, their storage period and shelf life can be extended, and the freshness and commodity of fruits and vegetables can be kept better. Air-conditioned storage can extend the storage period by 2~3 times than that of cold air storage.

Air-conditioned storage can reduce the oxygen concentration and increased carbon dioxide concentrations in the storage environment, combined with the temperature and humidity conditions, in maintaining the fruits and vegetables under the premise of normal life activities, effectively inhibit
respiration of fruit and vegetable, evaporation, and the role of microorganisms, extend the fruit maturation and aging, prevent metamorphic, thus achieve the goal of prolong storage life. The application of the new PLC control equipment for fruit and vegetable preservation can achieve the following purposes:

2.1. In response to our country's positive promotion of fruit and vegetable storage technology with air-conditioned storage. Due to the high post-harvest loss rate of fruits and vegetables in our country, and the large gap between the technology level of preservation and that of foreign countries.

2.2. Establish a practical and advanced air conditioning storage control system in line with our country's national conditions. There are many problems such as high cost, inadequate equipment management and imperfect supporting technology. To establish an air conditioning storage suitable for the characteristics of fruits and vegetables and environmental control in our country, can not only saves the cost, but also realizes the training of personnel, the maintenance of equipment and the improvement of supporting technology.

2.3. Reduce the loss of fruits and vegetables. During storage, fruits and vegetables are in a good dormancy state, which reduces their own consumption, and makes cherries, ginger, garlic and garlic more nearly fresh in weight, color, nutrition, hardness, appearance, taste, water loss and special smell.

2.4. Extend the preservation time. Because of the adoption of temperature parameter self-tuning PID technology and the oxygen concentration parameter self-tuning PID technology, carries on the negative feedback closed-loop control, optimized the air conditioning storage environment, inhibited the fruit and vegetable's metabolism rate, causes the storage period to extend greatly, usually is the ordinary storage time 1.5~2 times.

2.5. The program is easy to change. The design of the fruit and vegetable control system of air conditioning storage adopts PLC technology, easy to realize the cherry, ginger, garlic and garlic bolting control program conversion and adjustment, saving time and effort.

2.6. Save energy and reduce the cost of air conditioning storage. Due to the large power consumption of the refrigerator and the nitrogen generator, the air-conditioned storage uses two frequency converters, one for the refrigerator frequency control of motor speed, the other for the nitrogen generator frequency control of motor speed, so as to achieve energy-saving operation, change the current of the open and close mode scheme controls of the refrigerator and nitrogen generator in the air conditioning storage management.

3. Scenario Analysis

3.1 The mathematical model of the control system is established by using the self-tuning PID technology, the temperature and oxygen concentration of the air conditioning storage were well regulated.

3.2. Select sensors with converter circuit to complete automatic detection and transmission of temperature, oxygen, carbon dioxide, ethylene, humidity and other environmental factors.

3.3. Choose Mitsubishi PLC for hardware design and software design, control the refrigerator, electric heater, nitrogen machine, carbon dioxide removal machine, ethylene removal machine and humidifier operation, so as to adjust the temperature, gas composition and humidity of the air conditioning storage.

3.4. Two Mitsubishi frequency converter are selected for energy saving regulation, one for the refrigerator frequency control of motor speed, the other for the nitrogen generator frequency control of motor speed.
3.5. Select configuration to monitor the operation status and display data information of the air conditioning storage.

3.6. Carry out the test of frequency conversion and energy saving operation, and summarize the energy saving effect.

The control flow chart is shown in Figure 1.

Figure 1. Design flow chart.
4. Systematic Design

4.1 System Technical Indicators

According to the above analysis results, temperature, oxygen concentration, carbon dioxide concentration, ethylene concentration and relative humidity are the key parameters for storage and freshness preservation in the air conditioning storage. Taking ginger storage as an example and combining the design requirements of the project, the technical indicators to be achieved in this system are determined as shown in Table 1.

| Indicators            | Parameter | Precision |
|-----------------------|-----------|-----------|
| Temperature °C        | 12~14     | ±0.5      |
| Oxygen concentration %| 2~5       | ±2        |
| Carbon dioxide concentration % | 2~5       | ±2        |
| Ethylene concentration ppm | <10       | ±2        |
| Relative humidity %   | 85~95     | ±5        |

4.2 System Control Scheme

The air conditioning storage control system is a collection system of temperature sensor, oxygen sensor, carbon dioxide sensor, ethylene sensor, humidity sensor and other information acquisition system, test the temperature, humidity, gas composition and other environmental parameters in the storage. Through the control equipment to the refrigeration unit, electric heater, nitrogen machine, carbon dioxide removal machine, ethylene removal machine and humidifier and other executive agencies to control, adjust the environment in the air conditioning storage, to achieve the requirements of fresh fruits and vegetables.

The system using PLC as the controller to automatic control of actuator. The inverter control refrigerating machine and nitrogen making machine are designed, energy saving control is realized. The monitoring system of the upper computer using MCSG configuration software and communicates with PLC to display and record the data for real-time monitoring.

In order to improve the reliability of the system, automatic control mode and manual control mode are designed.

4.2.1. Manual control mode. Manual control mode is characterized by simple and reliable, composed of buttons, contactors and other electrical components.

4.2.2. Automatic control mode. Realize automatic control through PLC, use various sensors to detect the environment in the air conditioning storage, and set the upper limit and lower limit, beyond the set value will send out control signals to drive the actuator and inverter to open and close, in order to achieve the purpose of automatic control. Its characteristic is to save manpower, reduce operation cost, realize energy-saving reduce consumption.

4.2.3. Hardware design of the system. The hardware design of the system includes the selection and configuration of PLC, the design of information acquisition system, the design of actuator system and the design of inverter control system. Manual/automatic switching mode is adopted for flexible and convenient control. By communicating with the upper computer, the real-time monitoring function is realized.
5. Application Effect

5.1. Realized real-time control and stabilized the environment system of the air conditioning storage. The temperature, oxygen concentration, carbon dioxide concentration, ethylene concentration and humidity are automatically detected and transmitted to PLC by various sensors. Through PLC processing and operation, output control signal to control the refrigerator, electric heater, nitrogen machine, carbon dioxide removal machine, ethylene removal machine and humidifier operation.

5.2. The environment system of fruit and vegetable air conditioning storage is a time-varying, nonlinear and lagging system. Therefore, a design scheme based on parameter self-tuning PID technology to control temperature and oxygen concentration is established, and through the simulation software to carry on the simulation, the optimal control of temperature and oxygen concentration of the air conditioning storage was realized.

5.3. Realized energy-saving operation. Two inverters are used to speed the refrigerator and the nitrogen generator. Taking the test of variable frequency speed regulation for refrigerator as an example, the advantages of variable frequency speed regulation are summarized, such as fast cooling speed, small temperature fluctuation and good energy saving effect.

Taking the refrigerating machine frequency control of motor speed as an example to carry out frequency conversion energy saving test. Test time: October 20-21, 12 o’clock at noon in operation, the outside temperature is 20 °C, the temperature setting of the ginger to 13 °C, as time changes, the temperature regulation of variable frequency refrigerator and power frequency refrigerator is shown in figure 2.

5.4 Realize the dynamic monitoring of the air conditioning storage. The configuration software shows the running status of the storage in real time.

6. References

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