One Monitoring Device Design for Cold Storage Based on Energy Saving

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Abstract. Fresh agricultural products and rare Chinese medicinal materials have certain requirements on the temperature of cold storage in the store. In view of this problem, this paper designs a cold storage monitoring device to ensure the quality of fresh products, and solve the energy consumption in cold storage. The device includes temperature sensor, controller, alarm device, liquid crystal display, refrigeration unit and so on. Three aspects including control structure, air change device, refrigerant module are designed. This design can increase the refrigeration time of refrigerated items and the edible taste of food refrigerated items, reduce cooling energy consumption, it can be widely used in fresh products, Chinese medicinal materials, vegetables and fruits frozen preservation.

Keywords: cold storage, monitoring device, design.

1. Introduction
There are many problems in cold storage in China, such as poor insulation effect of cold storage construction materials, improper selection of refrigeration equipment, high energy consumption, low efficiency, backward production technology and unscientific management. According to the electricity consumption of cold storage, the energy saving of cold storage in China lags far behind developed countries [1].

In addition to the high energy consumption of cold storage, cold storage is generally built in the suburbs, adjacent to the production area, which brings great inconvenience to the management. Therefore, the use of automatic monitoring system to improve management efficiency has important practical significance [2]. Some rare Chinese medicinal materials, such as pseudo-ginseng and gastrodia elata, have certain requirements on the cold storage temperature, which is higher than or lower than the optimal cold storage temperature, which will reduce the cold storage time and affect the taste of food, and the existing cold storage in the process of refrigeration energy consumption. So in order to reduce energy consumption and inconvenient manual management in cold storage, this paper is try to design a simple monitoring device for cold storage which could be integrated into the cold storage
management system, which can increase the quality of cold storage items and reduce energy consumption.

2. Review of cold storage monitoring equipment
By the end of 2019, the construction area of cold storage in China has reached 7784259 m², and the total cold storage inventory is 45,973803 tons, which increases by an average of 10% every year [3]. Japan is the largest producer of frozen food in Asia. Low-temperature storage below -20°C accounts for more than 80% of the total cold storage [4]. As of 2017, American cold storage has a total capacity of 360 million m³[5]. According to statistics, the electricity consumption of refrigeration equipment in China accounts for about 15% of the national electricity consumption, among which the refrigeration equipment in cold storage accounts for a large proportion. In the composition of refrigeration costs, the cost of refrigeration power system exceeds 25%[6]. As the condensing temperature increases, the condensing pressure also increases, so that the exhaust pressure of the compressor increases, the compression ratio increases, the gas transmission coefficient of the compressor decreases, and the power consumption increases. For every 1°C reduction in condensing temperature, the compressor power consumption decreases by 19.5%, so reasonably lowering the condensation temperature is also an important part of the energy saving of cold storage [4]. This paper adopts precooling treatment of outdoor gas to achieve the purpose of energy saving.

3. Design contents
The device that controls temperature changes is connected to a controller, a refrigeration unit, and an alarm device. The refrigeration unit includes air exchange module, which is equipped with heat exchanger.

3.1. Control structure design scheme
The temperature in the cold storage is detected by the temperature sensor and transmitted to the control device. The control device and the pre-set cold storage temperature information are used for judgment and processing. When the temperature is higher than the maximum preset temperature, the alarm device will alarm, and the control device will control the refrigeration unit for refrigeration, so as to control the temperature of refrigerated items in the cold storage, increase the refrigerated time of refrigerated items and the edible taste of food refrigerated items. Through the cold and heat exchange between the old air in the cold storage and the fresh air outside the cold storage, the fresh air is pre-cooled, thus reducing the energy consumption in the refrigeration process. The structure flow chart is shown in figure 1 below.

3.2. Design of air changing device
When the temperature is measured by the central control module, the temperature will be controlled. Previous air exchange in cold storage adopted the direct outward exhaust method or the air curtain method to prevent the effect of indoor and outdoor wind pressure and hot pressure, which would generate a strong heat and humidity exchange at the cold storage gate, leading to an increase in cooling load [7]. During the use of the air changer, the fresh air outside the cold storage is sent to the exchanger (position 3), while the old air inlet inside the cold storage (position 1) sends the air inside the cold storage to the heat exchanger. The heat exchanger conducts cold and heat exchange for the injected air, and cools the new air. The fresh air after cooling reaches the air outlet (position 4) and enters the cold storage, while the old air is discharged into the outdoor air through position 5(seeing figure 2).

3.3. Design of refrigerant module
The refrigeration unit is connected with the power supply, and the electric switch and control device of the refrigeration unit are connected. At the same time, the old air inlet in the cold storage sends the old
air in the cold storage to the heat exchanger, which carries out cold and heat exchange and precools the fresh air. The fresh air after precooling reaches the cold storage through the fresh air outlet, and the old air is discharged into the air through the old air outlet. The temperature sensor constantly detects the real-time temperature in the cold storage. When the real-time temperature information of the cold storage is greater than the maximum preset temperature, the alarm device gives an acousto-optic alarm. At the same time, the controller issues the control command, the electric switch of the refrigeration unit is closed, and the refrigeration unit begins to work. When the real-time temperature is less than the maximum pre-set temperature, the alarm stops alarming, and when the optimal temperature value is reached, the refrigeration unit stops working.

3.4. Design of cold storage monitoring module
While the fan is changing, the temperature sensor continuously detects the real-time temperature in the cold storage, than compares the real-time temperature information of the refrigerator with the pre-set temperature. When the real-time temperature information of the refrigerator is greater than the maximum pre-set temperature, the alarm device will alarm the sound and light. At the same time, the controller issues control instructions, the electric switch of the refrigeration unit is closed, and the refrigeration unit begins to work. When the real-time temperature is less than the maximum pre-set temperature, the alarm stops to alarm. When the optimum temperature value is reached, the refrigeration unit stops working, thus saving the energy consumption during the refrigeration process.

![Figure 1. Control structure.](image1)

![Figure 2. The design of air changing device.](image2)

4. Summary
The main purpose of this design is to increase the refrigeration time of refrigerated items and the edible taste of food refrigerated items, and reduce the refrigeration energy consumption. A cooling module is set up to precool the exchange airflow, thus reducing the energy consumption in the refrigeration process. Moreover, by setting the liquid crystal display, the temperature information detected by the temperature sensor can be displayed in real time. Through the temperature sensor to detect the temperature in the cold storage. The signal is transmitted to the control device, and the control device and the pre-set cold storage temperature information are used for judgment and processing. When the temperature exceeds the maximum pre-set temperature, the alarm device will alarm, and the control device will control the refrigeration unit for refrigeration. The console of this design is limited to a fixed monitor. If the kingview system and ZigBee communication system can be added to communicate the data of the cold storage with the background central control system in real time, the management complexity will be greatly reduced.
Acknowledgements
This work was supported by the Opening Fund of Key Lab of Process Analysis and Control of Sichuan Universities of China (2018002), and by the Social Science Youth Project of Yunnan agricultureal of China (2015SK03).

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