Application of Intelligent Technology in Cold Storage Control System

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Abstract: With the development of my country's economy, the application of intelligent technology of cold storage control system is more and more popular. The application of intelligent technology in the cold storage control system is conducive to the optimized operation of the cold storage. Not only can it reduce energy consumption, energy saving and environmental protection, but also has networked and humanized management in control management. Therefore, the cold storage control technology has developed rapidly. This paper analyzes the application of the current cold storage control system, and focuses on the application and development of the main intelligent technologies in the cold storage control system.

1. Introduction
With the continuous growth of the national economy, cold storage has been widely used in industry, agriculture, Marine industry, commerce and many other aspects. but my country's cold storage automation level is relatively backward, and energy consumption has long been the consensus in the industry. Therefore, the application of intelligent technology plays an important role in the cold storage, not only to ensure that the system achieves safe and stable work, improves the system performance, but also to save resources and reduce costs, so the use of intelligent technology can not be ignored. This article briefly introduces the application of intelligent technology in the cold storage control system based on the current popular intelligent technology and my experience in work and study.

2. The application of frequency conversion (VFD) control in the cold storage control system
2.1. Inverter control compressor
Almost all rotary screw compressors in cold storage refrigeration equipment are unloaded using slide valves. This method is infinitely adjustable and provides reasonable inspiratory pressure control. However, part load performance decreases with lower suction or higher discharge pressure. Economy compressors usually lose economizer operation at about 75% of the sliding position. Below this position, compressor operation is not energy efficient. Therefore, we use a frequency converter (VFD) to control the compressor to maintain a constant suction pressure by continuously adjusting the speed of the variable speed compressor. For multiple screw compressors, a single inverter and a single compressor can be used to make the compressor flexible to start and the temperature fluctuation of the cold storage is small. A variable speed compressor controlled by a frequency converter can also be
provided and connected in parallel with multiple fixed speed compressors. VFDs such as Danfoss’ VLT drives can effectively manage open-loop or closed-loop control tasks in such compressor units. The advantage of using cascade control compressors is to reduce the number of compressors in each system and reduce the cost of providing the same capacity or better capacity [1].

2.2. Frequency converter controls pumps, fans and other equipment
For multiple chillers in each warehouse, one inverter can be used to control multiple motors. The main function of the warehouse fan in the refrigeration system is to make the temperature of each point in the warehouse uniform. By setting the starting temperature of each fan to become worse, switching between power frequency and frequency conversion, controlling stable temperature fluctuations and reducing operating costs to achieve energy saving purposes. The cooling water pump of the cold storage control system has high requirements for the start and stop control of the cooling pump to stabilize the condensing pressure due to the large motor power. The direct start and stop sprain the pipe network and equipment. Therefore, when the inverter is used for variable speed control operation, it also needs to use variable frequency soft start and soft stop to meet the normal operation and energy saving requirements of the pump.

3. PLC control application in the cold storage control system
PLC has become more and more obvious in industrial control due to its small size, low cost and special functions. It has been widely used in electrical control in power generation, chemical industry, electronics and other industries. Using PLC to realize the control of the cold storage control system can ensure that the cold storage refrigeration system is in an efficient, energy-saving and optimal operating state. Using PLC to control the cold storage system can realize the following automatic control functions of the cold storage: (1) Automatic safety protection and alarm of the cold storage system. Equipment high and low pressure protection, in addition to box temperature protection, motor overload protection, time delay startup protection, etc. (2) Automatic temperature adjustment and setting in the warehouse. With real-time temperature acquisition, temperature setting and backlash setting, temperature verification and compensation correction. (3) Automatic defrosting of the evaporator. Defrosting temperature setting, defrosting time and period setting, you can control the defrosting according to the temperature or through the time interval. After the defrosting is over, the delay start protection. (4) The refrigeration compressor is automatically turned on and off, and the condenser, evaporator, and compressor are turned on, delayed, and set in order according to the program control. (5) Sensor fault diagnosis and alarm, fault diagnosis and alarm for temperature sensor and pressure sensor. (6) Adjust and set the best working conditions through the touch screen, and monitor the temperature, pressure, humidity and CO2 in real time. (7) Working mode setting, automatic and manual conversion, single machine operation debugging and maintenance, and forced defrosting of cold storage. (8) It has the function of RS485 communication interface with other equipment layer devices, and forms a network monitoring with the remote host computer.

Because PLC has many advantages such as powerful function, reliable use, easy maintenance and so on. And combined with the intelligent control method, the refrigeration device is kept operating under the most economical and reasonable working conditions; the interactive input touch screen technology is used to monitor the refrigeration system of the cold storage and intuitively and visually introduce various information to On-site operator. Through the adjustment of the best working conditions, the food can maintain the best quality in the cold processing and refrigeration process, which brings great convenience to the user and saves energy at the same time, so as to achieve the purpose of reducing operating management costs.

4. Application of fuzzy control in cold storage
Fuzzy control FLC (Fuzzy Log Cont01) is one of the earliest and most widely used important branches in the field of artificial intelligence. It is suitable for problems with complex structure and difficult to model with traditional theory. Fuzzy control is an intelligent control based on rules. Based on fuzzy
mathematics, it is mainly composed of four basic components, namely, fuzzy interface, knowledge base, decision logic unit, and de-fuzzy interface. The control idea of the fuzzy controller is to take the state parameters of the refrigeration system as input and output are the execution commands of the refrigeration system.

4.1. Using fuzzy control theory to achieve optimal control of the system

The use of fuzzy control has gradually become the trend of cold storage development. According to the temperature sensors in each cold storage, the temperature value in each cold storage is measured and the corresponding temperature change rate is obtained. Fuzzy neural reasoning is used to adjust the temperature of the food refrigeration process in the storage, and then the opening degree of the expansion valve is controlled to achieve the best operation. Condition and the best fresh-keeping effect [2]. At the same time, according to the actual operating state of the cold storage, automatic frosting is selected in the storage, which reduces the impact of the temperature rise on the food during the defrosting process in the cold storage.

4.2. Using fuzzy control to achieve comprehensive control of cold storage

For controlled objects such as non-linear, time-varying, strong coupling between multiple parameters, large random interference, and complicated process mechanisms, the traditional PID control is adopted, the control overshoot is large, the adjustment time is long, and the control effect is relatively high difference. As an advanced control technology, fuzzy control has unique advantages in solving such problems. To apply this control strategy to engineering practice, it must be realized by a control system composed of corresponding hardware and software. Programmable controller PLC is a very suitable choice. It is widely used with a series of advantages such as small size, strong function, flexible and universal, convenient maintenance, high reliability, strong environmental adaptability, etc. One of the big pillars. Therefore, the combination of fuzzy control technology and PLC technology can realize the online self-tuning of PID parameters, making it have the characteristics of strong robustness, strong adaptability and high control accuracy. In the control, the PLC first performs fuzzy PID calculation on the actual deviation value and the change rate of the deviation value according to the environment and the temperature of the cold storage, adjusts the PID parameters of the PLC, and transmits the calculation result to the compressor's inverter to change the compressor's Frequency, control the amount of air delivered to the condenser or cooling capacity. As shown in Figure 1

![Figure 1 Control system structure](image)

Fuzzy control is based on comprehensive judgment of the refrigeration parameters of the cold store, and an optimal control scheme is obtained. The main advantages of fuzzy control applied to cold storage are the following. ① Reduce the energy consumption of cold storage. Because the cooling capacity of the refrigeration unit is well matched with the load, the energy loss of the main equipment of the cold storage is reduced when starting and stopping, thus improving the energy efficiency ratio of the equipment work. Experiments show that the combination of fuzzy control and frequency conversion can save about 30% in cold storage. ② Reduce the impact of cold storage equipment on power grid. After
the fuzzy control is adopted, the compressor motor adopts a soft start mode, the starting current is small, and the impact on the power grid is small. After the fuzzy control is adopted, the cooling capacity of the cold storage has a large change range, which can be applied to a variety of working conditions. Therefore, the temperature fluctuation in the cold storage is small, the operation noise is low, and the energy saving and consumption reduction are high.

Therefore, the application research of fuzzy control technology in cold storage automatic control has been in-depth, and the control target parameters tend to be diversified; in terms of control strategy, simple fuzzy control based on lookup table method has been developed to intelligent fuzzy control.

5. Application of Internet of Things technology in cold storage
The Internet of Things is through a variety of information sensing equipment and systems (sensor networks, radio frequency identification systems, infrared sensors, laser scanners, etc.), bar codes and two-dimensional codes, global positioning systems, according to agreed communication protocols, Things, people and things are linked together, and information is exchanged through various access networks and the Internet to realize an intelligent identification, positioning, tracking, monitoring and management of an information network.

The application of the Internet of Things technology in the food cold chain storage and transportation process is mainly used for real-time monitoring of temperature changes during storage and transportation. In cold chain transportation, especially in the case of long-term marine transportation, it is often because the cold can not be monitored in real time. The temperature changes during the chain transportation, even if the temperature exceeds the warning line of the system, it can not be alarmed, causing the food to rot and deteriorate [3]. Li Yang and other teachers from the School of Information Science and Technology of Hainan University designed an intelligent monitoring system based on the Internet of Things technology for the temperature and humidity monitoring and information management in the refrigerated truck transportation. This system is based on the concept of the Internet of Things and uses advanced RFID technology, sensor technology, GPRS/GPS technology and other wireless communication technologies together with the Internet form an intelligent system for remote monitoring of refrigerated trucks, which can real-time monitor the temperature and humidity, door switch status, and cargo information in the refrigerated truck box in real time. The location and tracking of the vehicle position realizes the entire monitoring and traceability of the entire transportation process, and achieves intelligent monitoring of the entire refrigerated truck transportation process. This system implements a modular design and consists of a multi-point temperature and humidity acquisition module, door switch monitoring device, RFID module, in-vehicle monitoring module, GPRS/GPS module, wireless communication network, and remote monitoring center. The block diagram of its system is shown in Figure 2.

![Figure 2 Internet of Things technology intelligent control system composition](image)

Relying on advanced Internet of Things technology, the system combines the existing sensor technology and wireless communication technology to achieve real-time and accurate monitoring purposes. A high-temperature temperature and humidity sensor constitutes a temperature and humidity acquisition module for real-time reading of temperature and humidity data in the vehicle box [4].
6. Conclusion
With the advancement of science and technology and the continuous improvement of people's requirements for cold processing of food and refrigeration, the application of advanced intelligent technology in the cold storage control system has also been more and more widely valued. Due to the continuous development of refrigeration control technology, modern intelligent control methods such as frequency conversion technology, PLC control technology, fuzzy control, and the combination of Internet of Things to optimize the control of the cold storage control system are the future development trends of control technology in the field of food cold processing and refrigeration.

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References
[1] Hao, J.X. (2016) Cold storage Construction and Automatic control of refrigeration System [J]. Cold Storage Technology, 2: 35-39.
[2] Yu, Y.Q. (1995) SCM fuzzy logic control. Beijing Aerospace Capital Publishing House, Beijing.
[3] Liu, D.H, Zhang, A.P. (2010) Internet of Things technology and its application in food storage and transportation [D]. In: Proceedings of the 2010 International Conference on Agricultural Engineering. Shanghai. 419-423.
[4] Li, Y., Zhang, Y.H. (2010) Intelligent monitoring system for refrigerated vehicles based on Internet of Things technology [J]. Communication Technology, 11: 59-61.