Application Research on Energy-saving Control Technology of Central Air Conditioning

Changbao Guo, yuping Li
Shandong Huayu Institute of Technology, Dezhou, Shandong, 253000, China
939712344@qq.com

Abstract: Modern society is facing an increasingly serious energy crisis, and building energy conservation has been paid more and more attention. In recent years, the country has attached great importance to the development of energy conservation and environmental protection industries. Therefore, central air conditioning energy conservation technology has become an emerging industry in the construction industry everywhere. It has played an important role in supporting economic and social development, driving the rise of related industries, and promoting energy conservation and emission reduction. The traditional central air-conditioning control system consumes a lot of energy while controlling a more suitable temperature. According to statistics, the energy consumption of central air conditioning accounts for more than 40% of the energy consumption of the entire building. The control technology of the traditional air-conditioning system is backward, which not only wastes a lot of energy, but also fails to meet the requirements of the new technology conditions. This article takes the central air-conditioning enterprises such as Yatai Group Co. Ltd., Zhongda Air Conditioning Group Co. Ltd, Shandong GRAD Group Co. Ltd. as the representative, to conduct the application research of the central air-conditioning energy-saving control technology to promote the application and development of the central air-conditioning energy-saving control technology.

1. Preface

With the continuous growth of the national economy, refrigeration and air conditioning have been widely used in many areas such as industry, agriculture, commerce, science and technology, and people's daily life. The application of energy-saving control technology has played a pivotal role in the air-conditioning industry. In the operation of the refrigeration system, if you want to ensure that the system achieves safe and stable work, improves the system's operating performance, so as to save resources and reduce costs, in the system operation, the use of energy-saving control technology can not be ignored. This paper takes the current central air-conditioning industry as the representative of the current state of the central air-conditioning energy-saving control technology of Texas Yatai Group, Zhongda Group, Shandong GRAD Group to conduct the application research of the central air-conditioning energy-saving control technology.

2. Central air conditioning energy consumption analysis

2.1. Central air-conditioning unit energy consumption

The equipment with the largest energy consumption in the central air conditioning system is the water chiller, which is divided into reciprocating (also known as piston) unit, screw unit and centrifugal unit according to the type of compressor, a screw unit and a centrifugal unit, and its power energy is
electric energy and heat energy (Lithium bromide models), according to their rated cooling capacity and cooling efficiency, the general rated input power from 100kw to 1000kw. The purpose of a chiller is to produce chilled water at a low temperature (7°C), so the temperature of the supply (outlet) water directly affects the load of the chiller. How much the terminal air handler starts will also affect the return water temperature of the chilled water. The return water temperature is high and the unit load is large.

2.2. Water pump
The chilled water circulation pump (abbreviation: chilled pump) mainly provides the power of the chilled water circulation. Its input power is generally from 11kw to 132kw. The traditional design of the chilled pump is a constant flow pump, and the output power is constant. The cooling water circulation pump (abbreviation: cooling pump) mainly provides the power for cooling water circulation. Its input power is generally from 11kw to 132kw. The traditional design of the cooling pump is a constant flow pump, and the output power is constant. The cooling tower fan mainly provides wind power for cooling water temperature. Its input power is generally from 3kw to 15kw. The traditional design of the cooling tower fan is a constant speed fan, and the output power is constant.

2.3. End device
The air processor (fan coil, water-cooled air cabinet) is the terminal equipment for indoor air temperature regulation, where the fan provides the power required for indoor air circulation, usually a constant speed fixed air volume fan, rated power from 0.5kw to 15kw, But the number is large. The new fan, return fan, and exhaust fan provide the power for fresh air supply, return air, and exhaust air. The rated power is generally from 2kw to 55kw.

The design of the central air conditioner is often designed according to the local meteorological data (highest/lowest temperature) and the characteristics of the building, and taking into account the maximum energy (cold/heat) requirements, 10% to 20% of the design surplus must be reserved Capacity, so the main unit, pumps, fan have a large margin. Due to seasonal rotation and time changes, the central air conditioner runs at maximum power throughout the year for a short time, generally less than 1%, so a large number of constant speed motors have great energy saving potential. Central air conditioners that do not have a central centralized monitoring system often result in greater energy waste due to use and management issues. The low maintenance awareness of users is also one of the reasons for the decrease in the efficiency of central air conditioning.

3. Application of central air-conditioning energy-saving control technology

3.1. Central air conditioning water system frequency conversion control scheme
The internal energy-saving mode of the air-conditioning host is generally to perform frequency conversion control on the compressor, achieving high-precision control so that the host will always be in the best operating state when the indoor load changes. Can achieve an average annual energy saving of more than 30%. At low load, 70% energy saving is achieved. When using multi-machine parallel cooling mode to run under non-full load conditions, start all compressors when starting up. When the outlet temperature of chilled water drops below 8°C, work at full load for 1-1.5h and then turn off some compressors. The frequency conversion operation of the compressor maintains the cooling capacity. At this time, the outlet temperature of the chilled water will fluctuate at 9-12°C, which can still meet the cooling needs and has a significant energy saving effect.

The speed regulation technology applied in the central air conditioning water system is mainly achieved by changing the motor speed of the circulating water pump in the chilled water system according to the change in the pump energy consumption. Select refrigeration pump frequency conversion subsystem, cooling pump frequency conversion subsystem, cooling fan frequency conversion subsystem, automatically detect the temperature of chilled water and cooling water,
automatically adjust the chilled water pump (heat pump), cooling water pump, cooling fan to make it in the best economic operation state. At the same time, it can reduce the waste of cold (heat) in the pipeline circulation.

3.2. Application of PLC control technology in energy saving of central air conditioning

With its small size, low cost, and special functions, PLC has become increasingly obvious in industrial control applications, and has been widely used in electrical control in power generation, chemical, and electronics industries. Using PLC to control the central air-conditioning system can ensure that the central air-conditioning system in the building is in an efficient, energy-saving and optimal operating state. Adopt PLC to control the central air-conditioning system, in-depth understanding, detailed analysis, and careful study of the characteristics and requirements of the process flow of the controlled objects (temperature, pressure, etc. air-conditioning operating parameters), clarify the control tasks, scope, and requirements. According to industrial indicators, reasonably formulate and select control parameters, so that the PLC control system can meet the process requirements of the controlled object to the greatest extent. Because PLC has many advantages such as powerful function, reliable use, easy maintenance and so on. And combined with the intelligent control method, the original constant flow system is changed to a variable flow control system, so that the operation of the pump units and cooling tower fans of the central air conditioner changes synchronously with the change of the load, which can ensure the load demand. Under the premise of achieving the maximum energy saving of the central air conditioning system [2].

3.3. Application of EMC system control technology in energy saving of central air conditioning

The system mainly includes monitoring of main parameters such as chilled water inlet and outlet water temperature, cooling water inlet and outlet water temperature, evaporating pressure, condensing pressure, host current, host load rate and other parameters. Units with a PC interface can directly obtain the unit operating parameters through its data communication protocol and realize remote control. If there is no PC interface or data communication protocol of unknown equipment, the simulation and quantification of each monitoring parameter can be realized through transmission components such as temperature sensor, pressure sensor, electric quantity sensor, etc., and it will be converted into a digital signal by the data acquisition card or data acquisition module. Network and workstation computer realize data communication. The EMC system is based on the premise of comfort control and scientific management and energy-saving optimized operation. The chiller operation management system aims to greatly reduce the labor intensity of central air conditioning system operators, improve the unit management level, and save manpower costs. The system has wide adaptability and great flexibility, and has the universality and individual differences of energy-saving operation of the central air-conditioning system. Figure 3 is a structural diagram of the EMC system. Figure 1 EMC system structure.
3.4. The realization of fuzzy control in the central air-conditioning energy-saving control system

At present, PID control methods are still widely used in the control field, and the inconvenience in selecting and adjusting PID parameters is still a common problem. Because fuzzy control introduces human's logical thinking mode, the fuzzy controller has certain adaptive control capabilities, strong robustness and stability, so it is particularly suitable for practical systems without accurate mathematical models [3]. The application research of fuzzy control technology in the field of central air-conditioning has been in-depth. The control target parameters have been developed from single temperature control to the control of comfort index; in terms of control strategy, simple fuzzy control based on look-up table method has been developed to intelligent fuzzy control. Figure 2 is the central air-conditioning fuzzy control system.

![Figure 1 EMC system structure](image1)

![Figure 2 Fuzzy control system of central air conditioning](image2)
3.5. Application of artificial neural network in the field of central air conditioning

An artificial neural network is an active network that imitates the human brain nervous system, uses a simple calculation-processing unit (neuron) as a node, and uses a certain network topology. It simulates the information processing, storage and retrieval functions of the human brain nervous system at different levels and levels. Many scholars have made many useful attempts, such as load forecasting, energy management, system identification, fault diagnosis, nonlinear control systems, and intelligent control. For example: Jan F. Kreider uses neural networks to predict the power consumption of a large hotel integrated conference center. Erik Jeannette uses ANN predictive controller (BP algorithm, multi-step prediction) to control the fan coil hot water system. The neural network identifier/controller can achieve two indicators: minimum set point error and low energy consumption of the HVAC system. Tests under different operating conditions and different dampers (valves or dampers) prove that the combined controller has wide application range, good robustness and high accuracy [4].

As people's living standards improve, people's requirements for life comfort are also increasing. Air conditioning, as an important tool in daily life, brings a lot of convenience to people. As the demand for air conditioning increases, various science and technology related to air conditioning are constantly developing. The application of neural network algorithm in air conditioning control system not only improves the efficiency of the system, but also improves the fault tolerance of the air conditioning system. In recent years, the gradual improvement of neural network control theory has made the application of neural network algorithms in the field of air conditioning gradually mature. Neural network control theory has gradually become a hotspot in the field of technical personnel, and the air conditioning industry has studied it and development also tends to mature.

4. Conclusion

With the progress of science and technology and the continuous improvement of people's requirements for the comfort of air conditioning, the application of advanced energy-saving control technology in the field of central air conditioning has been paid more and more attention. In recent years, China has attached great importance to the development of energy conservation and environmental protection industries. As an emerging industry in the construction industry in various regions, central air conditioning has played an important role in supporting economic and social development, driving the rise of related industries, and promoting energy conservation and emission reduction. Central air-conditioning manufacturing enterprises according to the national strategy of energy conservation and emissions reduction, also focus on developing ground source, water, air source, solar source, such as new type of air conditioning heat pump units, and frequency conversion technology, PLC control technology, fuzzy control, EMC system, artificial neural network system is the combination of modern intelligence such as high efficiency and energy saving control technology applied in the field of central air conditioning, make get rapid development in the field of central air-conditioning energy saving. Thus driving the rapid development of energy conservation and environmental protection industry.

Acknowledgments

In the research of central air-conditioning energy-saving control technology, I often visit major central air-conditioning companies for field visits, and have received strong support from the technical department of the enterprise, and offer selfless technical help. Thank you very much! At the same time, I also want to thank the teachers who helped me and encouraged me in writing the thesis.

references
[1] Yan, Q.SH. Design and Implementation of Central Air Conditioning Energy Saving System. Journal of Electric Power System and Automation, 2003, (1): 91-94.
[2] Zhang Li. Reform design of central air conditioning control system based on PLC and frequency conversion technology [J]. Application of Motor and Control 2012, 39(7): 54-57.
[3] Li Yujie. Application of intelligent fuzzy control technology in energy-saving control of central air conditioning [J]. Power Demand Side Management, 2007, 9(5): 77-78.

[4] Shen Shiyi. Theory and application of neural network system [M]. Beijing Science Press, 2010, 132-181.