Research on temperature and humidity decoupling control of clean air conditioning system

Cuicui Huang¹, *, Yulei Zhao²

¹²Engineering and Technology R&D Center of Clean Air Conditioning in Colleges of Shandong, Shandong Huayu University of Technology, Dezhou 2530334, China
*Corresponding author’s e-mail: 274466502@qq.com

Abstract: In the clean air conditioning system, in order to ensure that the temperature and humidity in the room are within the allowable accuracy range, it is necessary to control the dew point temperature. However, due to the inconsistency of the temperature and humidity control systems, the delay and inertia time constant of each channel are very different, so the dew point temperature is difficult to control. In order to achieve accurate control, multiple valves are opened at the same time in the system, which leads to energy loss, and usually a single circuit works normally. But when multiple chains work at the same time, the system is not easy to be stable. Therefore, in order to ensure the long-term safe operation of multi-parameter control system, making full use of mature technology and single variable control experience is an effective method to manage multi-parameter system.

1. Introduction
Saving resources is China’s main national policy. China’s building energy consumption accounts for 46% of the total social energy consumption, in which the highest proportion of building energy consumption is air conditioning energy consumption. At present, there are many research results on temperature control of central air conditioning using single variable, but there is no research on two-dimensional temperature and humidity control. The profiles of temperature and humidity control interact and interfere with each other, which is obviously not appropriate if the faults between cycles are not calculated. Therefore, the troubleshooting between temperature and humidity control circuit ensures stable operation, accurate control and energy saving is of great significance.

2. Development history of air cleaning technology
‘Clean air’ behavior refers to the clean ‘state’ where clean air is located. The purpose of air purification is to use some means, methods and equipment to purify the polluted air to the required state of service life or certain purity. In scientific experiments and industrial production, the accuracy, miniaturization, high purity, high quality and high reliability of product processing require that the concentration of dust particles can be controlled in the production environment. In the early 1980s, the United States introduced high-efficiency particulate air filter, marking the first leap in clean technology. In the early 21st century, the United States and other countries introduced modern industrial Cleanroom Technology in the field of microbial air pollution to control dust particles in the air.

3. Difference between clean air conditioning and general air conditioning
The general air conditioning mainly controls the temperature, humidity, fresh air volume and noise of
the space, while the clean air conditioning focuses on the control of the dust content, wind speed and ventilation frequency in the room. The temperature and humidity are also the main control parameters of the rooms that need to be controlled, and these parameters directly affect the quality, accuracy and purity of products [1]. In order to eliminate the influence of indoor exhaust on the atmospheric environment, it is necessary to set exhaust filtration or exhaust purification in the exhaust system according to various conditions. In order to avoid the infiltration of external pollutants into the interior or the interaction of various substances in different areas of the clean room, clean air conditioning has different requirements for the pressure difference in different areas of the clean room. In order to avoid external pollution, there are special requirements for the selection of materials and equipment, processing technology, processing and installation conditions and storage conditions of equipment components for clean air conditioning system. Air tightness requirements although the air conditioning system tends to put forward some requirements for air tightness and air permeability of the system, the requirements for clean air conditioning system are much more stringent than those for general air conditioning system. The test methods and standards of each process have strict measures and test requirements. Usually, in the air-conditioned house, the layout of the building, heating equipment and so on are required, but the selection requirements are not very strict. In addition to the requirements for the overall appearance of the building, the use of clean air conditioning to evaluate the quality of the building puts forward strict requirements for dust, dust and leakage [2]. Strict requirements are imposed on the construction technology and key links to avoid leakage caused by cracks. Clean air conditioning system for other types of work is also very strict, mainly pay attention to leakage, prevent polluted air into the clean room, and prevent dust into the clean room.

4. Decoupling design of temperature and humidity

4.1. Decoupling principle of linear multivariable process control system

Since 1960s, process control engineering has made great progress in theory and practice. Many complex and successful control schemes have been adopted in industrial production. However, for multivariable process control system, both engineering and theoretical circles agree that it is an advanced and complex process control system. Its advanced point is that it can effectively control some production processes with multiple interrelated variables, but this function cannot be completed by some artificially simplified single variable process control system. Its complexity is that it needs some more complex equipment than the single variable process control system, which makes the structure of the system more complex. From the perspective of cybernetics, advanced and complex means that the control system can meet some higher control requirements or control indicators, thus surpassing the conventional single variable process control theory in the depth and breadth of theoretical analysis.

The famous American Chemical Control scholar once pointed out that multivariable control has been widely valued by the academic and industrial circles of automatic control since the 1990s, and competed to study it [3]. However, the correlation between multivariable process variables, i.e., coupling, is an important reason for the poor operation of many control systems. The so-called coupling means that the change of one process variable will inevitably affect the change of other process variables. It is a common phenomenon in the dynamic characteristics of production process, because the production process is coordinated with each other, and the change of one process variable inevitably involves the change of other process variables (See Fig. 1).
4.2 Temperature and humidity decoupling control design of clean air conditioning system

Fig. 2 shows the diagram of coupling objects of temperature and humidity system. This is a coupling object with two inputs and two outputs\textsuperscript{[4]}. If the hot water valve \( u_1 \) controls the room temperature \( t_o \) and the cold water valve controls the room humidity, \( n \) constitutes two separate single loop control systems, or uses the hot water valve \( u_1 \) to control the room humidity, and the cold water valve \( z \) controls the room temperature \( t_o \), forming two separate single loop control systems. If the two systems are not well controlled, the existence of coupling will significantly reduce the regulation quality of the control system\textsuperscript{[5]}. Therefore, in order to solve this problem, it is effective to adopt certain decoupling control.

5. Conclusions

This paper introduces the fault control principle of linear multi-parameter process in detail. According to the basic principle of HVAC, the moisture content is introduced as an intermediate variable to control the dew point of the machine\textsuperscript{[6]}. Due to improper use of the humidity channel of the hot water valve, the compensator is directly connected to the cold water channel, so that the temperature and humidity system can be used to solve the problem.

Acknowledgements

This research was supported by “Engineering and Technology R&D Center of Clean Air Conditioning of Shandong Huayu University of Technology.

References

[1] Chaogang Zhang. Building Automation System in the Pharmaceutical Business Clean Air conditioning. Value Engineering, 2013, 32 (16): 58-59.
[2] Hongying Tan, Jiahua Hu. Air Conditioning System of Clean Operating Room and Control of Fresh Air Volume. Scientific and Technological Innovation, 2009 (32): 64.
[3] Haiquan Chen. Research on the application of building air conditioning automatic control system. Wuhan: Wuhan University of Technology, 2006.
[4] Liang Cao. Research on variable Air Volume control based on predictive control technology [D]. Huazhong University of Science and Technology, 2006.
[5] Ying Li. Study on temperature and humidity decoupling Control of automatic control System for Clean Air Conditioning [D]. Xi’an University of Architecture and Technology, 2008.
[6] Qinhua Hu. Decoupling control of VAV unit based on neural network -order inverse system. Xi’an University of Architecture and Technology, 2003.