

Study on hydraulic balance of HVAC water system

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Abstract

With the development of China's economy and the change of energy structure, the cooling and heating projects of public buildings in China are continuously optimized. As the air conditioning water system often used in public buildings, the air conditioning water system not only brings a comfortable environment but also brings a huge energy loss. Among them, the hydraulic balance problem of air-conditioning water system has always been the research direction of many research scholars. This paper briefly describes the development of the hydraulic balance of air conditioning water system in recent years, that is, the study and the problem of air conditioning water system in the actual engineering project, and puts forward their own opinions on the problem of the hydraulic balance of air conditioning water system.

Keywords

HVAC water system; variable flow; hydraulic imbalance.

1. Introduction

In 2018, the total energy consumption in the whole life cycle of buildings in China was 21.47tce, accounting for 46.5% of the national energy consumption, among which the energy consumption in the building operation stage accounted for 46.6% of the whole life cycle of buildings.[1] Among them, the energy consumption of air conditioning accounts for about 40%-50% of the building energy consumption, and the energy consumption of air conditioning water system accounts for 39% of the air conditioning energy consumption [2].

Under the background of the current Russo-Ukraine war, the energy situation at home and abroad is grim, and the problem of hydraulic imbalance in the operation of HVAC water system is one of the important reasons for the high energy consumption of HVAC operation. Therefore, it is of great significance to study the hydraulic imbalance of HVAC water system in building operation, especially in large public buildings.

2. Water imbalance of HVAC water system

At present, there are two main problems of hydraulic imbalance, one is the problem of fixed flow, the other is the problem of variable flow.

For the HVAC water system, it is mainly used in large public places. Due to the large project scale and complex building functions, this kind of building often causes the hydraulic imbalance caused by the problem of variable flow hydraulic imbalance.[3]In addition, in order to adapt to the real-time change of building load demand, the HVAC system usually adopts the variable flow system to realize the distribution of the flow in the network, and the key problem is also to ensure the hydraulic balance of the variable flow system.[4]

According to the engineering research examples of previous scholars, the first step is to solve the static hydraulic imbalance after taking some measures to solve the static hydraulic imbalance. Other scholars propose the comprehensive control theory, namely considering the

static hydraulic imbalance and dynamic hydraulic imbalance, but in the actual HVAC flow system design, the static hydraulic imbalance is often solved first, followed by the dynamic hydraulic imbalance. In order to achieve the water balance of the HVAC water system of the project, Engineering designers and construction personnel play an irreplaceable role, and give their own views from different perspectives of engineering design.

2.1. Balance valve / Control valve

Whether it is static hydraulic imbalance, or dynamic hydraulic imbalance, the invention and application of hydraulic balance valve and control valve is the key measure to realize the hydraulic balance of HVAC water system.

In the design stage, the economic flow rate is often selected to reach the control system resistance to a certain extent. In the initial adjustment of the system operation, the proportion adjustment method, the basic principle of hydraulic condition analysis and calculation, the compensation regulation method and the return temperature regulation method of the pipe network which lacks the regulating valve are often used to alleviate the degree of hydraulic imbalance.[5] However, in the actual engineering, due to the complex factors of the engineering situation, the problem of hydraulic imbalance between the design stage and the actual operation is still more serious. At this time, more use of valves for adjustment. Pan Yanchang et al. mentioned such as ball valve, butterfly valve, stop valve and other commonly used in engineering water supply and drainage design valve regulation performance and unable to measure the adjusted flow and other factors which cause in the actual engineering installation and debugging and operation management is extremely inconvenient. Therefore, the hydraulic balance valve specially used in the HVAC water system has been promoted and applied in the engineering projects[6] With the application of hydraulic balance valve in engineering, the construction personnel found that the ordinary hydraulic balance valve can not be completely coordinated with the actual hydraulic working conditions, and there is still a lack in the control of the flow. Gradually, the emergence of new valves such as automatic flow balance valve, differential pressure balance valve, dynamic balance two-way valve and dynamic balance electric control valve has further provided convenience for the hydraulic balance of HVAC water system. Wang Xiaosong gave the calculation and selection method of the electric regulating valve in the hydraulic balance.[7] But the high price of the electric regulating valve also increases the project budget.

Although the balance valve and control valve realize the purpose of hydraulic balance of the HVAC water system to a certain extent, due to the local resistance of the balance valve or control valve itself, it is necessary to improve the pump head to overcome the pipeline resistance, bringing extra energy consumption. Cao Qi in comparative analysis using the import balance valve, ZETA balance valve, isolation valve of constant pressure variable flow system and application system thinking concept of all similar variable pressure flow system comparison found that the system with balance valve and regulating valve energy saving against the operation of the system, and the installation of static balance valve also increases the engineering cost. [8] In the practical engineering application, due to the cumbersome design process and other reasons, the current HVAC hydraulic imbalance problem is still mainly alleviated or solved by adding balance valve or control valve.

2.2. Frequency conversion technology

The emergence of frequency conversion technology provides a new solution to the problem of HVAC water system. In meet the requirement of heating and cooling and ensure reasonable hydraulic balance, Wang discusses the temperature difference, dry pipe pressure and terminal pressure control three main operation control way next pump variable system flow system to avoid water imbalance of cold and heat distribution and "low temperature difference syndrome" problem, and analyzes the three control methods in different system flow change of

energy saving effect.[9] After the analysis of the flow system of frozen water transformer, Zhang Huiying found that the primary pump transformer system has good performance in the energy balance of HVAC water system.[10] In the operation and adjustment process of the secondary pump transformer system, He Li found that when the engineering hydraulic situation of the secondary pump is more complex, taking the secondary pump transformer system has more advantages for the hydraulic balance and energy saving performance of HVAC.[11] At the same time, When Zhao Chunhong analyzed the efficiency of the secondary pump of the HVAC flow water system and the chiller, he found that the cold and heat source and circulating pump in the HVAC secondary pump transformer system often could not operate with large load, which caused the low efficiency of the equipment to a certain extent and increased the overall energy consumption of the HVAC water system.[12]

Through the actual engineering situation and past cases, the engineering designer found that the secondary pump transformer system in the HVAC water system with large building structure, the designed water resistance and the same design, the secondary pump should be set centrally; if the water temperature or temperature difference of each system is different, the secondary pump should be set according to the area or the system.[13]

2.3. Design and installation of water system supporting pipe network

The supporting water system pipe network can well alleviate the problem of hydraulic imbalance of the HVAC water system. Zhang Jinjin analyzed the common problems in the design of HVAC water system and put forward three ways to take energy saving measures for water system, to improve the control level and to design the envelope structure of water system reasonably.[14] Wang Su discussed the HVAC water system scheme, and analyzed the HVAC water pipe system scheme, namely the basic two-pipe system, partition double-pipe system, three-pipe system and four-pipe system.[15] In order to alleviate the degree of hydraulic imbalance in the HVAC water system, the layout scheme of Reverse Return Mode water system is mostly used in the HVAC water supply and return pipe in the project. Guo Zongmin et al. concluded through engineering example study that when the HVAC water system of high-rise hotels is selected and arranged similarly, the local resistance loss between each loop of the pipe network is similar, and Reverse Return Mode water system has better hydraulic balance compared with Direct Return Mode water system[16] yet, Reverse Return Mode water system Setting up the extra return water pipe causes more cost for the project, Jiao Hongzhao calculated from the HVAC water system of the same route pipeline in an office building that when most equipment pipelines are Reverse Return Mode water system, Direct Return Mode water system Choose a large pipe diameter at the pipeline, Controlling a small specific friction resistance can still maintain a good hydraulic balance condition, Compared with the overall use of Reverse Return Mode water system in the building, it not only reduces the loop radius and pipe, but also achieves the purpose of energy saving due to the choice of small pump head.[17] Ji Guohui points out the importance of the correct installation of the equipment by analyzing the construction factors of the HVAC water system on the performance of the HVAC water system [18]. Zhang Jianli et al. pointed out with the project example that the reasonable debugging of the hydraulic balance of the HVAC water system during the construction process can play an important role in ensuring the operation of the system and energy conservation. [19] Pan Li elaborated the relevant technical requirements and suggestions for the production and installation, water pipe support and hanger, installation, pressure test, insulation and protection of pipes. [20] Zhang Lizhu further analyzed the pipeline design work and equipment installation requirements in the installation and construction of the HVAC water system, and analyzed the water circulation problems of the water system and the solutions.[21]

3. Conclusion

In the research on the hydraulic balance problem of HVAC water system, although scholars in different industries have given different insights, there are still many problems to be solved in the practical engineering application. How to take into account many factors to reduce or even avoid the hydraulic imbalance of HVAC water system to save energy needs to be further discussed.

In recent years, with the development of science and technology, technologies in emerging fields are gradually applied to traditional industries. Based on the application research of automatic control theory in HVAC water system, different scholars have put forward their own relevant opinions. However, there are many reasons that have not been widely promoted at present, such as the small scale of the project, and the energy consumption cost caused by the hydraulic balance problem is smaller than the introduction of targeted automatic control system for buildings. So, based on the research progress of the above scholars, there are the following two suggestions:

(1) Investigate the actual situation of the project, take measures according to the local conditions, study the hydraulic balance of the completed project HVAC water system design scheme, and then conduct the HVAC water system design of the new project.

(2) Develop the digital project of the HVAC water system to realize the visualization of the data of each pipeline during the operation of the HVAC water system, and combine the application of automatic control theory in the HVAC water system to provide prerequisites for precise regulation and mitigation of the problem of hydraulic imbalance.

Acknowledgements

The work was supported by the Natural science foundation of Liaoning province (No.20180550636) and the Scientific research projects of institutions of higher learning in Liaoning province (No.2019LNJC14).

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