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Development and application of valve control method at customer end

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Abstract: Aiming at the problem that the centralized intelligent household control technology based on "consistent backwater temperature" can’t effectively solve the thermal imbalance of users, a room temperature control model is established according to the law of heat balance and heat transfer, and the reasons why this technology can’t effectively solve the thermal imbalance are analyzed by using the model. On this basis, with the help of the established room temperature control model, a centralized intelligent household control technology based on "backwater temperature compensation" and its implementation method are proposed. Using the centralized intelligent household control technology based on "backwater temperature compensation" can not only effectively solve the problem of thermal imbalance of users, but also realize the optimal control and energy-saving operation of heating system.

Keywords: consistent return water temperature; Return water temperature compensation; Centralized account control; Room temperature control model

1. Introduction

The user-side imbalance of central heating system is common. The user-side imbalance not only causes uneven heating and cooling, reduces heating quality and increases user complaint rate, but also greatly increases heat consumption, electricity consumption and water consumption, reducing the economic benefits of heating enterprises.

Household regulation is an important means to solve household imbalance. The traditional household control technology is to set a static balance valve at each household, and adjust the opening of the valve to match its flow with its heat load, thus eliminating the imbalance at the household. Because this kind of regulation is completed at the decentralized user end, it is called decentralized user end regulation technology. Decentralized user-side regulation technology can solve the problem of user-side imbalance in theory, but in actual operation management, it is difficult for operation managers to accurately regulate all users because of the large scale of users and the complex imbalance, which leads to the difficulty in achieving the expected effect of user-side regulation and even the ineffectiveness of user-side regulation facilities.

With the development of Internet of Things technology and related technologies, intelligent heating technology characterized by the high integration of information technology and central heating technology has also developed rapidly [1]. Under this background, the centralized intelligent household control technology characterized by centralized control has also been gradually popularized and applied.

2. Composition and characteristics of centralized intelligent household control system

Centralized intelligent user-side regulation technology is supported by Internet of Things technology and information technology, with the means of pipe network parameter measurement and prediction, data transmission, data processing and automatic control, aiming at accurate user-side parameter regulation, and has obvious intelligent characteristics.

The system of centralized intelligent household control technology is mainly composed of centralized control platform, decentralized household control facilities, wired or wireless communication networks and other data transmission facilities [2]. Among them, decentralized household control facilities are arranged at the thermal entrance of each heat user of the central heating system, including control valve body, actuator, control instruction receiving device, control parameter sensor, signal conversion and sending device, etc., to realize the functions of detecting and sending control parameters, receiving and executing control instructions, etc. The centralized control platform is equipped with user-side control information processing software, which is used to realize the functions of data acceptance, processing, storage, instruction generation and transmission. Wired or wireless communication network and other data transmission facilities include ""and so on, which are used to realize the transmission and exchange of communication data between centralized control platform and many user-side control facilities.

The operation of centralized intelligent user-side control system is generally carried out in the following four steps: first, the target values of user-side control parameters are set on the centralized control platform; Step 2, transmitting the data detected by the control parameter sensors of the user-side control devices to the centralized control platform through the data communication transmission network; Step 3, the centralized control platform compares the received detection data and set values of user-side control parameters one by one, and respectively issues control instructions according to the comparison results; Step 4, the user-side control device receives and executes the control instruction [3].

3. Centralized intelligent household control technology based on "backwater temperature control"

According to the different control parameters, the centralized intelligent household control system can be divided into system types based on different control parameters or indicators such as household flow, household backwater temperature, household heat and household room temperature. Among them, in the system with household flow and household heat as control parameters, the setting value of control parameters needs to be calculated according to the load situation of each user, and the calculated value often deviates from the actual required value, so it is rarely used; In the system with "room temperature at the user's end" as the control parameter, it is necessary to set a room temperature measuring device at a specific location in the user's room, and the measured room temperature value may not fully reflect the overall room temperature situation of the user, which may lead to control errors and affect its popularization and use; The system with the "return water temperature at the household end" as the control parameter has been widely used in the household control of central heating system because the return water temperature can intuitively reflect the corresponding relationship between the household flow and the household load, and the control logic is simple and the parameter measurement is convenient [4].

3.1 Limitations of centralized intelligent household regulation technology based on "consistent backwater temperature"

Centralized intelligent household control system with "return water temperature" as the control parameter usually takes the return water temperature of each user as the household control parameter, and sets the set values of the control parameters to be the same, that is, ensuring that different users have the same or roughly the same return water temperature as the control target of the system. In the actual regulation process, it is found that it is possible to adjust the return water temperature of all users to be the same or roughly the same by using this centralized intelligent household control system, but it is not difficult to find that some users still have the problem of too high or too low room temperature under the condition of the same or roughly the same return water temperature at the household end [5]. In other words, even if the return water temperature of all users is the same, there is no guarantee that all users can achieve real thermal balance.

The ideal goal of centralized intelligent household control system with "return water temperature" as the control parameter should be that the households have the same return water temperature and the room temperature can meet the requirements. Why is the return water temperature the same in the actual regulation process, but the room temperature is too high or too low? To understand this problem, we must first understand the internal relations among physical quantities such as indoor control temperature, outdoor temperature, heat dissipation intensity of envelope, heat load, heat medium water supply temperature, heat medium backwater temperature, heat medium flow rate, heat medium supply capacity, average temperature of heat medium, heat dissipation intensity of heating equipment and heating capacity of heating equipment.

The heat load of heat users depends on indoor control temperature, outdoor temperature and load intensity of envelope, which can be expressed by the following formula:

$$Q_1 = (K_1F_1)(t_n - t_w)\#(1)$$

In the formula, Q_1 is the heat user load intensity, unit (W), F_1 is Envelope area, unit (m^2), K_1 is the heat transfer coefficient of the envelope, unit $(W/(m^2 \cdot ℃))$, t_n is Indoor control temperature, unit (℃), t_w is outside temperature, unit (℃).

The heating capacity of heating equipment depends on the average temperature of heating medium, indoor control temperature and heat dissipation intensity of heating equipment, which can be expressed by the following formula:

$$Q_2 = (K_2F_2)\left[\left(t_g - t_h\right)/2 - t_n\right]\#(2)$$

In the formula, Q_2 is the heat supply of heating equipment, unit (W), F_2 isheat transfer area of heating equipment, unit (m^2), K_2 is the heat transfer coefficient of heating equipment, unit $(W/(m^2 \cdot ℃))$, t_g is water supply temperature of heat medium, unit (℃), t_h is backwater temperature of heat medium, unit (℃).

The heat supply of heat medium depends on the heating capacity of heating equipment, which can be calculated and determined according to the water supply temperature, backwater temperature and flow rate of heat medium [6]:

$$Q_3 = CG\left(t_g - t_h\right)\#(3)$$

In the formula, Q_3 is the heat supplied by heat medium, unit (W), C isspecific heat capacity of heat medium, unit $(W/(\text{kg} \cdot ℃))$, G is theheat medium flow, unit (kg/s).

When the indoor temperature is stable, Q1= Q2= Q3 holds. Then the following two expressions can be derived from formulas (1), (2) and (3):

$$t_n = \frac{K_2F_2\left(t_g - t_h\right) + 2K_1F_1t_w}{2(K_1F_1 + K_2F_2)}\#(4)$$

$$G = \frac{K_1F_1\left[K_2F_2\left(t_g - t_h\right) + 2K_1F_1t_w - 2t_w(K_1F_1 + K_2F_2)\right]}{2C(K_1F_1 + K_2F_2)\left(t_g - t_h\right)}\#(5)$$

It can be seen from Expression (4) that the user's room temperature depends on the load intensity of the user's envelope, the heat dissipation intensity of the user's heat dissipation equipment, the user's water supply temperature, backwater temperature and outdoor temperature. When the water supply temperature, backwater temperature and outdoor environment temperature are the same, because different users have different load intensity of envelope and heat dissipation intensity of user's heat dissipation equipment, the indoor temperature of users is different or even has a big deviation. This leads to the problem that all users' room temperatures are inconsistent, and even some users' room temperatures are too high or too low, if the "return water temperature" is the control condition in the centralized intelligent household control system with the "return water temperature" as the control parameter.

3.2 Centralized intelligent household regulation technology based on "backwater temperature compensation"

In order to solve the problem that the user's room temperature is uneven, too high or too low due to the control of backwater temperature in the centralized intelligent household-side regulation technology based on "consistent backwater temperature", a centralized intelligent household-side regulation technology based on "backwater temperature compensation" is proposed on the basis of the original regulation system.

The basic principle of this technology is that, according to the functional relationship between room temperature and load intensity of user's enclosure, heat dissipation intensity of user's cooling equipment, user's water supply temperature, backwater temperature and outdoor temperature revealed by expression (4), on the basis of measuring the load intensity of user's enclosure and heat dissipation intensity of user's cooling equipment, and according to the changes of heat medium water supply temperature and outdoor temperature, respectively calculate and determine the return water temperature of different users under the premise of meeting different user's room temperature conditions, and take this as it.

From the technical principle, it can be seen that it is the key to determine the set value of backwater temperature for each user to measure the load intensity of the user's envelope and the heat dissipation intensity of the user's heat dissipation equipment.

3.3 Calculation of load intensity of user's envelope

The load intensity of the user's envelope is a physical quantity representing the overall thermal insulation performance of the envelope, which indicates the heat lost through the envelope when the temperature difference between indoor and outdoor is 1 degree. Its value depends on the size of the user's envelope and the insulation status of the envelope.

For the users whose heating system has been put into operation, the load intensity of the envelope can be calculated according to the operating parameters of the heat users as follows: firstly, according to the measured supply and return water temperature and flow rate of the users, the heat supply of the heat medium is calculated by using formula (3); Then, according to the measured indoor and outdoor temperatures of users and the calculated heat supply of heat medium, the load strength of the envelope of each user can be calculated by using formula (1).

3.4 Heat dissipation intensity of user's heat dissipation equipment

The heat dissipation intensity of user's heat dissipation equipment is a physical quantity representing the comprehensive heat dissipation capacity of heat user's heat dissipation equipment, which indicates the heat released by the heat dissipation equipment when the heat dissipation temperature difference of the heat dissipation equipment is 1 degree. Its value depends on the heat dissipation area of heat dissipation equipment and its average heat transfer coefficient. The larger the heat dissipation area, the greater the average heat transfer coefficient, and the greater the heat dissipation intensity of the user's heat dissipation equipment; On the contrary, the smaller the heat dissipation area, the smaller the average heat transfer coefficient and the smaller the heat dissipation intensity of the user's heat dissipation equipment.

For users whose heating system is put into operation, the heat dissipation intensity of their heat dissipation equipment can also be calculated according to the operating parameters of heat users as follows: firstly, according to the measured supply and return water temperature and heat medium flow rate of users, the heat supply of heat medium is calculated by using formula (3); Then, according to the measured supply and return water temperature, outdoor temperature and the calculated heat supply of heat medium, the heat dissipation intensity of each user's heat dissipation equipment can be calculated by using formula (2).

After calculating the load intensity of the user's envelope and the heat dissipation intensity of the user's heat dissipation equipment, according to formula (4), the backwater temperature of each user at a specific room temperature, water supply temperature and outdoor temperature can be calculated, which can be used as the set value of the user-side control temperature of the centralized intelligent user-side control technology under this condition. Furthermore, according to Formula (4), the backwater temperature of users under the above different conditions can be calculated respectively according to different values or different combinations of values of room temperature, water supply temperature and outdoor temperature. Based on the "backwater temperature compensation", the centralized intelligent user-side regulation technology can change the set value of backwater temperature independently according to the changes of the above conditions and the corresponding calculation results, and realize the optimal regulation of the user.

4. Application

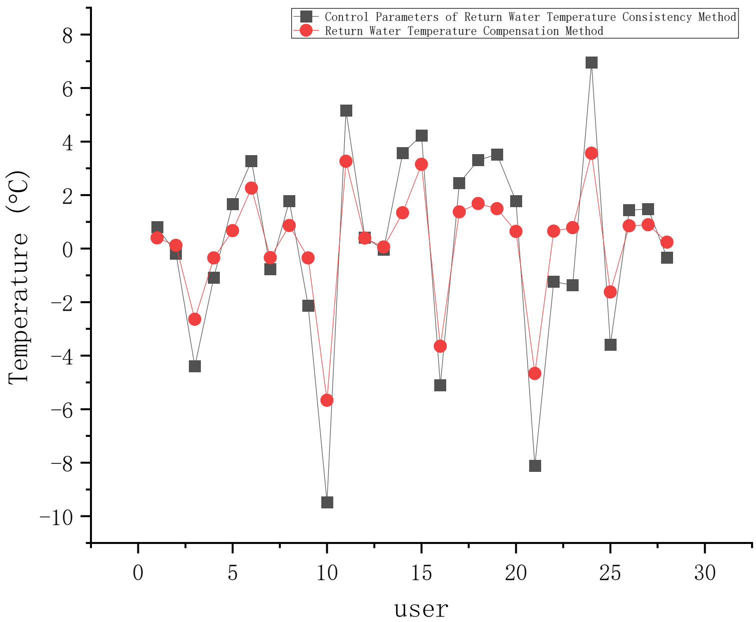

Figure 1: The temperature difference between the return water temperature consistency method and the return water temperature compensation method

A residential area adopts a centralized intelligent household control system based on "consistent return water temperature", and its control effect is shown in Figure 1. It can be seen from Figure 1 that the centralized control system with the consistent return water temperature at the user end has a large inconsistency in the indoor temperature of the user: the indoor temperature of the standard household (there are users on the left and right and normal heating) is generally higher, and the indoor temperature of the bottom household, the top household, the side household, the side bottom household, the side top household, and the island household have different degrees of reduction, especially the problem that the room temperature of the island household and the side top household is not up to standard.

After the transformation of the above-mentioned centralized intelligent user-side control system based on the method of "return water temperature compensation", its control effect is shown in Figure 1. The control parameters can be seen in Figure 1, and the user's indoor temperature deviation is greatly reduced by adopting the centralized control system of the user's return water temperature compensation. This not only avoids the waste of heat caused by uneven heating and cooling at room temperature, but also meets the comfort of most users and improves the quality of heating.

5. Conclusion

Cannot effectively solve the problem of thermal imbalance of users. According to the law of heat balance and heat transfer, the room temperature control model is established. The model is used to analyze the reasons why the centralized intelligent household control technology based on "consistent backwater temperature" cannot effectively solve the thermal imbalance. With the help of the established room temperature control model, the centralized intelligent household control technology based on "backwater temperature compensation" and its implementation method are put forward, which provides technical support for the optimal control and energy-saving operation of heating system.

References

[1] Liu Haiyan, Cheng Weijia, Niu Xiaohua, Wang Yujuan, Deng Xiaoqi. Data acquisition method of heating in northern civil buildings based on Internet of Things technology [J]. District heating, 2022,(02):108-116.

[2] Qi Xianbo. An intelligent control valve for secondary network based on smart heating framework [J]. Intelligent Building and Smart City, 2020,(02):64-66.

[3] Li Gengsheng, Chloe Wang, Sun Gang, Euro Celebration. Application analysis of intelligent two-network balance system based on backwater temperature balance method [J]. District heating, 2019,(01):66-70.

[4] Chen Tieqiang. Analysis of hydraulic maladjustment of heating pipe network and research on backwater temperature balance method [D]. Tutor: Wang Peng. Harbin Institute of Technology, 2019.

[5] Liu Chunlei, Wang Peiqi, Gao Tian, Wang Chen, Guo Lijiao. Research on intelligent regulating and balancing system of secondary network based on backwater temperature method [J]. Journal of Hebei Institute of Architecture and Engineering, 2021,39(02):113-116.

[6] Nie Yong. Discussion on the relationship between supply and return water temperature of central heating and outdoor temperature [J]. Energy Saving, 2014,33(02):49-52+3.