Intelligent Regulation System of Central Heating Pipe Network based on Internet of Things

Yiming Chen¹, Xiaogang Du¹,*, Yuhang Liu¹, Jiang He² and Wenli Chen²

¹School of Mechanical Engineering, Tiangong University, Tianjin, China
²Tianjin Jiuwo Energy Co., Ltd, Tianjin, China

*Corresponding author email: duxiaogang@tjpu.edu.cn

Abstract. The level of heating quality determines the comfort level of residents’ indoor life in winter. In order to effectively improve the hydraulic imbalance of the pipe network, improve the self-adjusting ability of the pipe network and reduce manual operations. This paper proposes an Intelligent Regulation System for Centralized Heating Pipe Network based on the Internet of Things, and takes the No.3 building of Guangxian Jiayuan Community in Tianjin as a pilot project to select the flow rate and return water temperature in front of the representative users in the low, middle and high floors Measure the date and analyze it. The results show that the flow of the indoor pipe network of the user runs smoothly, and the change range is within 0.05 m³/h, and the change range of the return water temperature of the pipe network is maintained within 3 °C. The Intelligent Regulation System of the Pipe Network has a good self-regulation capability.

Keywords: Internet of Things; Centralized heating; Pipe network balance; Intelligent adjustment.

1. Preface

The heating pipe network system has always had the following problems. The heat users at the end of the heating pipe network lack sufficient and effective adjusting means or subjective enthusiasm, such as not adding a temperature control valve, temperature adjustment panel, etc., due to hydraulic imbalance, some users have high indoor temperature, and there is no independent adjustment device indoors. Open windows to dissipate heat, which brings inconvenience to people’s lives[1,2]. There are deviations in the heating regulation design and matching of the heating area, resulting in poor regulation of the heating system and serious hydraulic imbalance. In order to meet the worst thermal conditions demand, blindly increase the system circulation, resulting in a huge consumption of system flow and heat[3,4]. The heating system has a low degree of automation and cannot automatically change the heat supply according to environmental changes, nor does it have a thermal compensation system that automatically adjusts the system according to users heat changes[5,6].

With the advancement of science and technology, scholars at home and abroad have been committed to the intelligent development of heating pipe network systems. Finnish scholar Pukancn[7] and others established a Web-based district heating information system, which can automatically optimize the hydraulic conditions of the heating system and accurately schedule the operation of the heating system. Lixin Li[8] fully affirmed the influence of building thermal inertia on heating quality. Simple manual operation cannot satisfy the dynamic adjustment of heating pipe network. It must rely on the computer's automatic monitoring system, and obtained the heat supply and circulation Dynamic equations of flow rate, temperature of supply and return water and related parameters of building...
thermal inertia. Le He[9] proposed an intelligent building balance system applied to the secondary network. After the system is applied to a community, the hydraulic balance of the building is maintained between 0.9-1.1, and the average indoor temperature of the user is maintained at 21.5 °C. At present, most secondary network adjustment systems collect and control the hydraulic and thermal parameters at the thermal entrance in front of the building. However, there are very few adjustment systems that are refined to the heating user's room at the end of the pipe network. Therefore, this article builds an intelligent regulation system for the secondary pipe network of Tianjin Guangxian Jiayuan Community, collects the circulating flow and return water temperature in the heat meter in front of the residents, and analyzes the regulation ability of the regulation system. It is hoped that the intelligent system can be applied to the operation and regulation of pipe network.

2. The Intelligent Regulation System of the Secondary Pipe Network

2.1. System Composition

As shown in Figure 1, the system is mainly composed of Heat Meter, DTU, Remote Control Platform, Electric Control Valve, and RTU.

![Figure 1. Intelligent regulation system of pipe network.](image)

2.2. System Working Mechanism

2.2.1. Structure and function of each component

(1) Heat meter

The heat meter is mainly composed of a hot water flow meter, a temperature sensor, and a totalizer[10], which records the heat, flow, and temperature of the supply and return water at the thermal entrance in front of the building.

(2) DTU

GPRS data transmission unit (GPRS DTU) is a wireless device that transmits serial data through the GPRS network[11], and transmits data to the remote control platform.

(3) Remote control platform

The remote control platform mainly analyzes, organizes, and stores data, and issues control instructions to the remote controller.

(4) RTU

The RTU can remotely control the equipment through the telephone or wireless network, and directly change the opening degree of the adjustment through the power supply to drive the regulating valve actuator[12].

(5) Electric control valve

Electric control valve is a device for flow adjustment in an automatic control system[13], which mainly adjusts the opening of its own valve and then adjusts the flow of the pipe network.

2.2.2. System working principle. The DTU data transmission equipment transmits the pipe network flow recorded by the heat meter and the supply and return water temperature data to the remote control platform. The remote control platform analyzes the data. If the actual flow of the pipe network
differs greatly from the designed flow, the remote control platform will pass the remote control. The controller adjusts the valve opening of the electric control valve to change the actual flow of the pipe network, thereby eliminating the hydraulic imbalance of the pipe network and realizing the hydraulic balance of the pipe network.

3. Application Practice

3.1. Application Background
Guangxian Homeland Community is located in Wanxin Street, Dongli, Tianjin. It consists of nine buildings, each with 15 floors and two residents on each floor. The heating method of residents is unified as radiator heating. According to the resident population statistics of each building in the community, there are people living in each household in Building 3, so Building 3 is used as a pilot. The "General Principles of Civil Building Design" stipulates that the first to third floors are low-rise residences; the fourth to sixth floors are multi-storey residences; the seventh to ninth floors are middle-rise residences; and ten floors and above are high-rise residences. Therefore, this article takes the users on the first, second, eighth, ninth, thirteenth, and fourteenth floors as representative users. Article 19 of the "Regulations on Heat Supply and Use of Tianjin" stipulates that the heating period of this city is from November 15th of the current year to March 15th of the following year. According to the actual temperature situation, the heating office of the Municipal People's Government shall make an advance or The decision to extend the heating period. The heating period from 2019 to 2020 is from November 1, 2019 to March 31, 2020. In this paper, the measured data of heat, flow, and supply and return water temperature will be collected from November 10, 2019, and the data will be read every 10 days until March 19, 2020, for a total of 14 days.

3.2. Theoretical Basis
The design heat load of the house and the design flow of the pipe network satisfy the following relationship:

\[ G = \frac{0.86Q}{t_g - t_h} \]  

In formula (1), G represents the design flow rate, m³/h; Q represents the design heat load, KW/h; t\(_g\) and t\(_h\) respectively represent the supply and return water temperature, °C.

During the heating period, hydraulic failure is often used to indicate the degree of hydraulic failure of the pipe network, that is, the ratio of the actual flow of the pipe network to the design flow.

\[ x = \frac{G_x}{G_g} \]  

In the formula (2), x is the hydraulic out of dispatch; G\(_x\) is the actual flow, m³/h; G\(_g\) is the design flow, m³/h.

4. Data Analysis

4.1. Users Pipe Network Traffic Analysis
Hydraulic imbalance is the main cause of uneven heat consumption by heat users at the end of the pipe network. After the heating period is over, the indoor pipe network flow of the sampled representative users is analyzed, as shown in Figure 2.
Figure 2. Represents users network traffic.

As shown in Figure 2, the flow of the pipe network representing the user runs relatively smoothly, and the difference between the highest flow and the lowest flow is kept within 0.05 m³/h. The results show that the intelligent control system can effectively eliminate the phenomenon of hydraulic imbalance and maintain the hydraulic balance of indoor pipe network.
4.2. Analysis of the Return Water Temperature of the Users Pipe Network

Remote adjustment of stations, buildings and indoor users based on the platform should be one of the basic functions of smart heating, and the return water temperature method should be used first to eliminate thermal imbalance. The return water temperature of representative user pipe network is analyzed. See Figure 3 for details.

![Graphs showing temperature variations over time for different user pipes.](image)

**Figure 3.** Pipeline return water temperature of represents users.

As shown in Figure 3, during the heating period, the return water temperature of the pipe network on behalf of the users is maintained within 3°C, indicating that the intelligent regulation system can still...
maintain the return water temperature of the pipe network when the water supply temperature of the pipe network changes stable.

5. Conclusion
This article draws the following conclusions by analyzing the data of users pipe network flow and return water temperature on the 1, 2, 8, 9, 13 and 14 floors of Building 3 in Guangxian Jiayuan Community.
1). The flow rate of the pipe network changes within 0.05 m³/h. The intelligent regulation system can effectively eliminate the hydraulic imbalance of the pipe network.
2). The return water temperature of the pipe network fluctuates within 3 ℃. The intelligent regulation system can effectively eliminate the thermal imbalance of the pipe network.
3). The pipe network intelligent adjustment system has good independent adjustment ability, reducing manual operation.

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