BIG DATA INFORMATION COLLECTION OF IoT FOR HEAT STORAGE HEATING CONTROL SYSTEM

by

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In order to understand the application of iot Big data information acquisition for heating control systems, a research on iot Big data information acquisition for thermal storage heating control systems is proposed. This paper first analyzes the shortcomings of the traditional heating system, the heating data is scattered and difficult to collect. The IoT technology is applied to the heating platform through data acquisition, data visualization, data mining, data management and other aspects. Secondly, the application of the IoT in heating system data acquisition is studied, including the types of heating data collected, data acquisition process, data acquisition standards, etc. Finally, this paper takes the energy-saving transformation of 26 boilers in a heating enterprise as an example. The research results show that the boiler efficiency obtained in real time by using the online monitoring system of this project is 95.36%, and the reverse balance boiler efficiency in the paper report of the special inspection office is 94.88%, with a deviation of 1.48%. The application of the IoT technology can obtain the boiler indicators in real time and effectively, and can realize the comprehensive analysis of the monitoring data, and realize the evaluation of the energy efficiency operation state of the gas boiler and the fault diagnosis and early warning. The IoT technology is an effective means of fine energy-saving management in heating enterprises.

Key words*: hydronics, Big data, information acquisition*

Introduction

The design of the heat storage heating control system based on the IoT technology, uses the IoT technology to transmit the collected real-time data to the cloud for storage, and then through the analysis and processing of the cloud data, realizes the real-time monitoring of the operation status of the heat storage heating system, user behavior, indoor environmental parameters and other related data, it provides a solution for real-time monitoring of the operation status of the regenerative heating system and indoor environmental parameters.

The core of IoT technology is wireless sensor network technology, which is composed of a large number of sensor nodes. Through various RF chips, microprocessors, and related supporting software on the sensor nodes, information collection and processing in the real world are achieved. Wireless sensor networks have characteristics such as self-organization, self-configuration, and self-healing, making them very suitable for application in the field of energy and environmental monitoring. When storing in the cloud, the system first preprocesses the collected real-time data, then uploads the preprocessed data to the cloud server using Cloud storage technology, and then the cloud server analyzes and processes the Big data information,

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so as to realize real-time monitoring of the operation status of the heat storage heating system, user behavior, indoor environmental parameters and other relevant data.

The country currently has the highest carbon emissions in the world, and carbon emissions are mainly concentrated in the fields of electricity, heat production, and transportation. With the implementation of the *carbon neutralit*y strategy, improving coal utilization efficiency and reducing carbon emissions will inevitably become an important direction for future demand side reforms. Under the promotion and encouragement of national policies, the central heating industry has developed rapidly in recent years. However, the rapid development has also revealed many shortcomings in the domestic heating industry. The heating industry has a large area in the northern region, and its energy consumption accounts for 9.7% of the national building energy consumption. However, the energy consumption per unit building area is three times that of developed countries in Europe and America. The significant gap in energy consumption is partly due to differences in building structures, and partly due to the fact that many regions in China still adopt relatively backward household measurement technologies. At present, the vast majority of heating charging methods are still based on the heating area, which not only cannot guarantee the comfort requirements of heat users, but also cannot achieve the goal of *on-demand heating and uniform heating*. Therefore, reasonable household metering heating technology cannot only meet users' comfort requirements, but also effectively reduce carbon emissions.

With the development of electronic sensor technology and communication technology, the application of IoT technology has brought many conveniences to household metering heating. The use of a large number of data collection terminal devices and intelligent measuring instruments enables household metering systems to more quickly and effectively obtain, statistics, and analyze end-user data [1, 2]. At present, remote meter reading technology closely related to household heat metering is mainly divided into wireless meter reading and wired meter reading. Wireless meter reading is a popular research direction based on the development of the IoT industry, such as bluetooth technology, zigbee technology, infrared technology, and GPRS technology. Wired meter reading technology has developed earlier and is more mature compared to wireless technology.

Literature review

The IoT technology is an emerging field of many technological convergence, including sensor technology, electronic information technology, AI technology, computer communication technology*, etc.* The IoT technology refers to the extension and anti war based on the Internet, utilizing electronic information communication technology to achieve the connection between things and people. The hydronics built based on the IoT mainly includes three parts, namely, the collection of heating operation parameters, the remote transmission of data information, and the analysis and management of heating operation parameters. Intelligent monitoring terminal is an important component of the heat storage and heating control system based on IoT technology. Its main function is to monitor and record the operating status of various devices in the heating system in real-time, and transmit the monitored data to the cloud for storage through wireless network. After analysis and processing, it is presented to users in the form of text and images. The intelligent monitoring terminal consists of three parts: a sensor, a data acquisition module, and a control module. The sensor of the intelligent monitoring terminal adopts a dual channel design of pressure and temperature, which collects indoor temperature through temperature sensors and room humidity through pressure sensors. In the control module, the intelligent monitoring terminal analyzes and processes the collected data, presents it to the user in text form, and sends control commands to the cloud. Users can adjust the operating status and indoor temperature of the heating system through the control module, achieving remote control of the heating system. The application of IoT technology in the field of heating can achieve real-time collection of heat load, real-time acquisition of user heating quality, and remote wireless transmission of data, thereby achieving the goal of *on-demand heating, uniform heating*. The application of IoT technology can connect hot users, property management, and heating companies, which is conducive to information transmission. The IoT technology in foreign countries has developed earlier in the field of central heating, so the household heat metering technology and its related data acquisition technology are more advanced. For example, Danfoss, Germany Siemens, Germany Daiao and other companies combine the IoT technology with advanced heat metering technology (*K* coefficient heat calculation method, M-BUS meter reading method) to build a more complete IoT architecture including sensors, network communication, and application analysis. In recent years, many domestic researchers and enterprises have gradually explored the application of IoT technology in the heating field. Emroozi *et al.* [3] has established a smart heating network operation monitoring system based on IoT technology, which can achieve joint regulation of the entire heating network by on-site stations and main stations. Egwuonwu *et al*. [4]. The actual project of heating metering transformation in a residential area in Beijing is a case, combining the IoT technology and heat metering technology, and through actual project case analysis, it shows the application prospect of the IoT technology in the hydronics.

The author designed a thermal storage heating control system based on IoT technology to address issues such as incomplete data collection and low data collection accuracy during the operation of the system. The real-time monitoring of the operation status, user behavior and indoor environmental parameters of the heat storage heating system is realized.

Methods

Data acquisition objects

The sources of heating data for civil buildings obtained based on the IoT technology include heat sources, primary networks, heating stations, secondary networks, and users. Table 1 lists common types of heating data collected based on the IoT [5, 6].

Data acquisition process

The platform structure for obtaining heating energy resource data using IoT technology usually includes the following contents: the PLC control cabinet, secure transmission gateway, VPDN, DMZ area, data acquisition front-end machine, database server, application server + production remote monitoring client, precise regulation algorithm, heat metering server, *Nb* IoT*, etc.* The following Steps 1-4 for data acquisition are explained using secondary network room temperature acquisition and precise regulation as examples, as shown in fig. 1.

Step 1. Obtain operating condition data: Obtain operating condition data such as temperature, pressure, flow rate, heat, opening*, etc.* at corresponding positions through the control cabinet of the heating station and the control cabinet at the entrance of the building.

Step 2. Obtaining indoor temperature data: Obtain indoor temperature data of residential heat users through the heat metering platform (wired) or *Nb* IoT platform (wireless).

Step 3. Data collection: The obtained working condition data and room temperature data (including the room temperature of the thermal metering platform or *Nb* IoT room temperature) are transmitted to the data collection front-end machine through a mobile APN network.

Step 4. Data storage: Store the data from the data collection front-end machine in the database server.

Table 1. Common examples of heating energy resources collected based on the IoT

Serial number	Data acquisition object	Obtain metrics	Collect parameters
1	Meteorological parameters	Outdoor temperature	Outdoor temperature
2		Temperature	Temperature
3		Wind speed	Wind speed
4	Heat source	Heat	Heat, temperature
5		Pressure	Water supply pressure
6	Primary network	Heat	Instantaneous heat of primary network
7		Flow	Instantaneous heat of primary network water supply
8		Temperature	Primary network supply, return temperature
9	Secondary network	Temperature	Secondary network supply, return temperature
10		Cycle frequency	Supply and return water temperature
11		Temperature	Supply and return water pressure
12	Building entrance	Pressure	Supply and return water pressure
13		Heat	Instantaneous heat
14	Indoor	Indoor temperature	indoor temperature

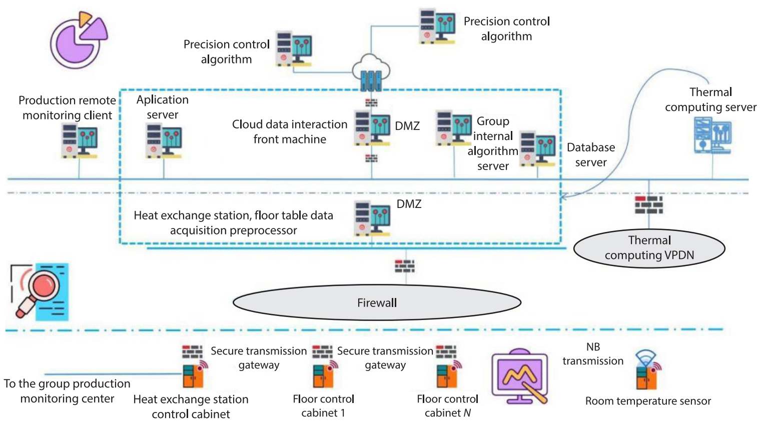

Figure 1. Data acquisition and transmission method of user's indoor temperature precise control platform on demand

Data acquisition standard requirements

At present, there is no unified standard for obtaining heating energy resource data based on the IoT. Table 2 discusses the accuracy, frequency, and other requirements for obtaining relevant data using secondary network room temperature acquisition and precise regulation as an example.

Table 2. Complete examples of standards for obtaining heating energy data based on the internet of things

Position	Data description	Unit	Atransmission frequency	Equipment
Heating station	Primary supply and return temperature	[°C]	12 minutes	Heating station control cabinet
Heating station	Opening of primary return branch valve	[%]	12 minutes	Heating station control cabinet
Heating station	Primary supply of instantaneous current and heat	[t per hour] [GJ per hour]	12 minutes	Heating station control cabinet
Heating station	Secondary side supply and return temperature	[°C]	12 minutes	Heating station control cabinet
Building entrance	Inlet supply and return water temperature	[°C]	12 minutes	Entrance control box
Building entrance	Heat meter transient flow, transient heat	[t per hour] [GJ per hour]	12 minutes	Entrance control box
Indoor	Temperature	[°C]	65 minutes	Heat metering platform

Experiments

Experimental subjects

The main implementation object of the project is a heating enterprise with a total of 25 boilers. Real time energy efficiency analysis is conducted on the boilers to improve resource and energy utilization, achieve the goals of boiler energy conservation and reduction of pollutant emissions. The main technical services include access to real-time monitoring data of remote gas boilers. Access to monitoring data of flue gas online monitoring system. Provide technical services such as energy efficiency operation status evaluation, fault diagnosis and warning for gas boilers through comprehensive analysis of monitoring data.

Implementation status

The project selects 25 boilers from four boiler rooms of a certain heating enterprise for pilot testing, and obtains real-time data on fuel consumption, water supply temperature, water supply flow, power supply*, etc.* of the boilers based on IoT technology. The online monitoring of boiler room energy efficiency is achieved using a reverse balance calculation method. Based on the actual needs of energy-saving and emission reduction work in a certain city, energy efficiency analysis is conducted on boilers through the measurement of various indicators to improve resource and energy utilization efficiency, achieve the goal of boiler energy conservation and reducing boiler emission pollution. Through real-time monitoring of boiler operating conditions, the operation status evaluation of gas fired boilers and real-time alarm of abnormal faults are achieved, ensuring the safety and stability of boiler operation .

Technical ideas

Four heat source plants are installed with 4G wireless routers, and the system adopts VPDN networking. The DCS system and CEMS system use the enterprise's existing VPDN dedicated network for communication, and the data is uploaded to the enterprise's real-time data center through a dedicated firewall. The energy efficiency monitoring system consists of a relational database and application service pages, with data provided by a real-time database.

Instrument and equipment situation

The main operating equipment involved in this project is 26 gas boilers, as shown in tab. 3.

Table 3. Instrument and equipment details

Serial number	Name of heating plant	Heating capacity or transfer capacity	Number
1	Heating Plant 1	5 units 58 MW, 2 units 40 t per hour, 3 units 75 t per hour	10
2	Heating Plant 2	10 units 14 MW	10
3	Heating Plant 3	6 units 58 MW	6

The project instruments are divided into production control layer, data transmission channel, and production management layer. The production control layer includes thermal power, pressure gauge, DCS operation station, DCS control cabinet, CEMS industrial control computer*, etc.*, distributed in the heat source plant. The DCS system and CEMS system use the existing VPDN dedicated network communication, and the production control layer includes energy efficiency analysis application servers, branch monitoring clients, and central monitoring clients. The recommended hardware environment requirements for the system are:

– Server configuration.

The CPU: 2 8-core Intel Xeon E74820 2.0 GHz.

Memory: Expands to 32G DDR3 DIMM 1.35v memory.

Hard disk: 4300 GB 2.6SAS hot swappable hard disks.

Network: 2100 GB Ethernet interfaces.

Power supply: Hot swappable redundant power supply.

Operating System: Microsoft Windows Server 2012 Enterprise Edition SP1 X64.

– The PC configuration (user browsing machine) CPU: Core i7 2400.

Data acquisition and analysis

By installing heat meter, pressure gauge, IoT remote transmission equipment*, etc.* in the boiler room, the project realizes the collection of main energy (water, electricity, natural gas, heat) data and transmits them to the centralized online monitoring system of heating boilers [7]:

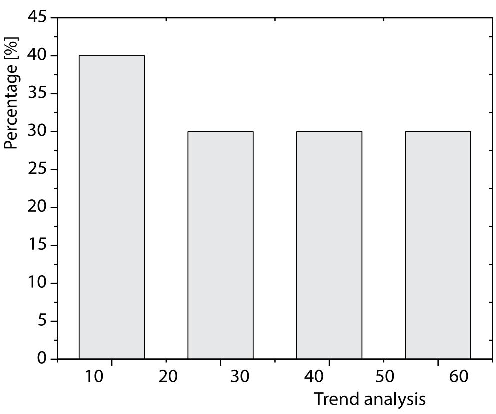

Figure 2. Analysis of usage trend of boiler online monitoring system

– Real time data online monitoring

The centralized online monitoring system for heating boilers adopts IoT technology to obtain real-time operating data of boilers, including fuel consumption, water supply temperature, water supply flow, electricity consumption*, etc.*

– Real time performance calculation of boilers

Based on the analysis of online monitoring data of boilers, grasp the real-time operation status of boilers, as shown in fig. 2.

– Boiler performance report

According to user needs, corresponding gas boiler performance monitoring reports can be generated, including energy efficiency test reports of boilers under various operating conditions, real-time monitoring data of boilers, and data reports of theoretical calculation results, as shown in tab. 4.

Table 4. Boiler online system monitoring data

Name	Collection time	Supply temperature	Thawing	Supply pressure	Accumulated heat	Instantaneous heating capacity	Export time
Boiler room 1	2021.12.14 10.08	103.4	50	0.94	28563	2695	2021.12. 1210.45
Boiler room 2	2021.12.14 10.08	102.3	52	0.78	24569	2459	2021.12. 1210.45
Boiler room 3	2021.12.14 10.09	96	54	0.56	102360	95332	2021.12. 1210.45
Boiler room 4	2021.12.14 10.07	88	55	0.42	123645	10453	2021.12. 1210.45
Boiler room 5	2021.12.14 10.09	108	53	0.21	154623	165	2021.12. 1210.45

– Historical query of alarm records

Alarm queries can be performed based on the alarm time interval or the alarm boiler.

– Test results

The real-time boiler efficiency obtained by selecting a boiler using the online monitoring system of this project is 95.36%, while the counterbalance boiler efficiency in the paper report of the special inspection institute is 94.88%, with a deviation of 1.48%. Please refer to tab. 5 for details [8].

Table 5. Comparison between online monitoring results of gas boilers and monitoring results of special inspection stations

Test parameters	Online monitoring equipment	Paper report of special inspection center	Unit
Rated output	118	118	[MW]
Circulating water volume	15636	1624536	[kg per hour]
Inlet water temperature	45633	465	[°C]
Outlet water temperature	1.23	100.4	[°C]
Test output	96.3256	95988	[MW]
Oxygen at smoke exhaust	3.99	4.65	[%]
Excess air coefficient at smoke exhaust	1.24	1.23	[5]
Smoke exhaust temperature	96	96	[°C]
Smoke exhaust heat loss	0.6	4.65	[%]
Heat dissipation loss	0.9	1.48	[%]
Simple testing efficiency	95.36124	94.88 Counterbalance	[%]

Analysis and evaluation of IoT technology in the application of heating data acquisition

Project innovation points

The innovation points of this project mainly include three aspects:

- Connect remote gas boiler real-time operation data and flue gas online monitoring system construction data, obtain the smoke exhaust loss and actual operating thermal efficiency of the boiler according to the reverse balance energy efficiency calculation method, obtain the relationship curve between boiler thermal efficiency and boiler load, and grasp the real-time operation status of the boiler.
- It is possible to generate corresponding performance monitoring reports for gas boilers based on user needs, including energy efficiency testing reports for boilers under various operating conditions (including the calculation process of boiler counterbalance efficiency), real-time monitoring data for boilers, and data reports of theoretical calculation results.
- It can achieve multithreaded computing and support data access, display, calculation, and storage for multiple gas boilers. Users can select any boiler site and time period for data display and analysis according to their needs [9].

This project adopts mature, advanced, practical and feasible energy-saving solutions and measures, and adopts advanced, mature, reliable, high efficiency, low energy and energy-saving equipment. From the perspective of architecture, HVAC, electrical and other professional aspects, energy-saving measures for each link are comprehensively considered.

The collected data shows that various energy supply and consumption systems have achieved effective measurement management and supervision. Through a series of energy-saving measures, while ensuring compliance with operational requirements and creating a comfortable indoor working environment, energy utilization efficiency is improved and energy consumption is minimized to the greatest extent. The energy consumption level can meet the various indicators of reasonable energy use in relevant national energy-saving standards and specifications. According to the current progress of the project, the energy consumption of electricity facilities has decreased by 4%, and the gas consumption of natural gas boilers has decreased by 1%, achieving good energy-saving effects [10].

Conclusions

Compared with traditional methods of obtaining heating data for civil buildings, IoT technology mainly has the following advantages:

- *Data validity*. In the process of data acquisition, human interference is reduced or even eliminated, achieving continuous monitoring and acquisition of heating condition data, and greatly improving the reliability of the data.
- *Data efficiency*. Through advanced intelligent technology, optimization is carried out from the individual and system layers of the equipment, effectively improving the efficiency of data acquisition, setting the frequency of data acquisition according to needs, meeting the needs of heating production management, and reducing operation and maintenance costs.
- *Data intuitiveness*. It can visually display real-time and historical data such as heating stations, building entrances, temperatures, pressures, flow rates, and user room temperatures on the platform, and can also achieve data alarm functions.

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