

Heat Metering System Characteristic and Energy-saving Analysis Based on On-off Time and Area Method

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Abstract. The article started with heat allocation formula analysis, the author studied on the on-off time and area heat metering system characteristics, and discussed influence factors of system characteristics which include temperature difference between supply water and return water, radiator type to fairness of heat allocation. Then analyzed the energy-saving effect in a practical heating system. The results indicate that heating energy saving rate of this system is more than the heating system without using on-off time and area heat metering method in similar building.

Introduction

The on-off time and area method heating metering system is a heating measurement method. In this heat metering system, on-off valve controller is installed in each household heating branch and controlled by room temperature. Users can also adjust the thermal requirements by themselves.

This on-off heating system's heat load is adjusted automatically based on users' set value of indoor heating temperature. Heat waste is avoided by using this technology. This metering heating system has been widely used in the northern city of China.

The paper expounds the principle of on-off and area method heat metering system at first, then analyzes the energy-saving effect in a practical heating system.

Principle of Heat Metering System

System Composition. The kernel of on-off and area method heat metering system is on-off valve controller and room temperature controller is shown in Figure 1. Room temperature controller is installed on each user's indoor at the same position that used to measure, display and set the room air temperature, and send on-off signal to valve according to the set of room temperature or the user command.

Room temperature on-off controller is used for calculating the on-off valve opening ratio in a heating cycle with the difference between room temperature and setting value. According to each user's opening ratio that is heating time ratio, the total building heat allocated to each household.

In order to alleviate the disturbance, the balance valve is usually installed in the system return water pipe, to reduce the hydraulic imbalance in pipeline caused by the variable flow.

Technology Principle. In heating period, a heating cycle consists of three stages: from open the on-off valve to the turn off to open. First stage, the room temperature is lower than the setting value, valve opening. Second stages, with room temperature gradually increased, the building envelope structure began to store thermal, after a period of time (Δt_1), room temperature rise to the upper limit, and the on-off valve is closed then enter the third stage. At this point, because of interaction between heating dissipation of building envelope caused by outdoor low temperature and heat retaining structure, after a period of time (Δt_2), room temperature drops to the lower limit, the on-off valve open and let the water through the indoor radiator. Above three-stage is a heating control process, shown in Figure 2. It represents even if the valve is turned off or on, indoor temperature will continue to rise or fall for a while due to the thermal inertia of the building envelope.

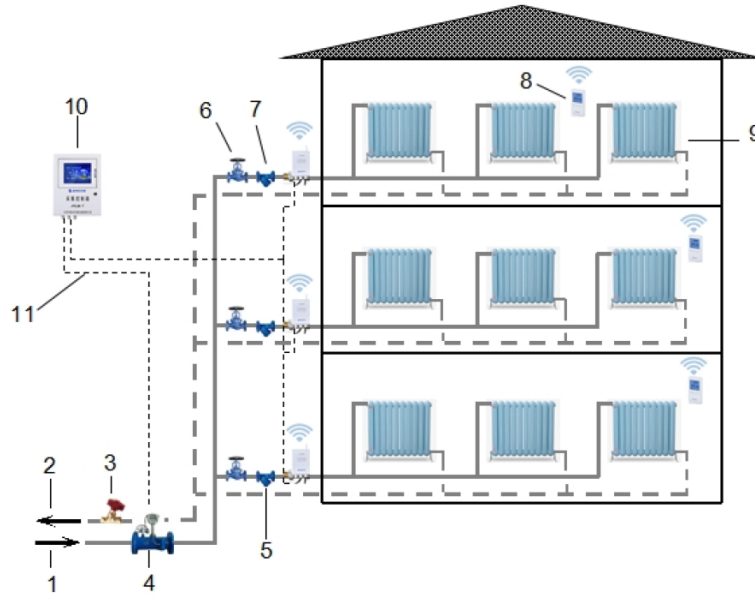


Fig.1 The on-off time and area method heating metering system

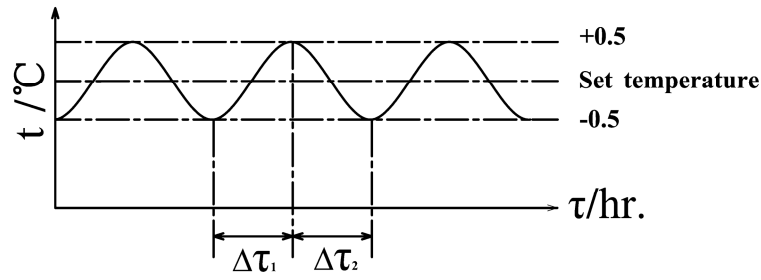


Fig.2 Indoor heating working condition in on-off regulating mode

The heat allocation of each user is calculated according to Equation (1).

$$Q_i = e_i \cdot S_i \frac{Q}{\sum_{i=1}^n e_i \cdot S_i} \quad (1)$$

$$e_i = \frac{\Delta t_i'}{\Delta t} \quad (2)$$

In Equation (1) and Equation (2), Q_i is heat consumption of user (i) in the allocation period, kW•h. e_i is on-off valve's open time ratio of user (i) in the allocation period; $\Delta \tau$ is total heat allocation time, $\Delta t_i'$ is total on-off valve's open time of user i in the allocation period. S_i is user (i)'s building area. Q is total building heating load, kW•h. n is the number of users who participates in heat allocation.

From Equation (1), each household's allocated heating load based on room building area and on-off value opening ratio, not equal to actual heat consumption. In literature^[1] the author proves the Equation.1 by experiment. In literature^[2] the author gives the supplement about the applicability of the Equation (1).

Influence factors of system characteristics

Supply and Return Water Temperature. Although this on-off system is a kind of heat metering system, however, because of the characteristics of the system, it has some differences compared with other heat metering systems.

From the derivation of equation (1) can be obtained the following views: If two users' heating design loads, operating condition and heating requirement (room air temperature) are the same, then on-off valve's open time ratio and the measured heat are the same. But in the actual heating process, there are different factors that make operation state deviate from the design values. Different factors have diverse effects on the system.

The premise of the formula hold of equation (1) is to ensure that the system temperature difference between supply and return water is constant. In the design stage in order to meet the extreme conditions, the design heat load is usually greater than the actual heat supply in the actual heating process. During the design phase in order to adapt the extreme weather, the design heat load is usually greater than the actual heat supply in the actual heating process. If the users according to thermal comfort of occupants to regulate the heat supply system, then the user's temperature difference between supply and return water is sometimes less than the design value. This situation may cause heat allocation unfair.

In the parallel individual-household-loop system, the change of each user's supply and return water temperature do not affect the heat allocation process. In one-pipe-series-loop system, when the water temperature rises, most disadvantageous user is affected most seriously, and when the water temperature decreases, most advantageous user is affected most seriously.

Radiator. During the design phase, in order to ensure the same indoor temperature, depending on the room construction area and room location, each user is calculated the radiator area, after construction is completed, the user should not be unauthorized alterations radiator.

In the parallel system, for example, when the same heating load into each user's room, if user A increases the radiator area, will shorten the on-off valve open time. In one-pipe-series-loop system, if user A increases the radiator area, the downstream user's water temperature will be lowered and the heating time will be increased. In series system, on-off valve controller and room temperature controller is usually installed in the most disadvantageous user's room, if certain heating condition make most disadvantageous users feel comfortable, it may also lead to supply excess heat to the upstream user. Floor heating system can also be used in on-off time and area method heat metering system, different materials floor also have great differences with the heat dissipating capacity. Heat dissipation of wood flooring under the same conditions is less than heat dissipation of tilt flooring about 30% to 40%^[3].

Related heating system

After the concept of heat metering systems have been proposed, the system is often used in vertical double-pipe system for new building (fig. 3). For existing building, there are two ways to make this new heat metering method can be applied to old heating system. First, if the vertical series system is transformed into a vertical single crossover-pipe heating system, it can also be used for on-off time and area method heat metering system (fig. 4). Second, the on-off control valve is placed on each standpipe; room temperature controller is placed in a typical room (generally in the middle of standpipe). These two devices regulate the flow of a single standpipe, and make all users' room on the standpipe have an appropriate temperature^[4].

It should be noted that when the vertical single-pipe system is used high-rise buildings. If there is the following case, such as user's difference between supply and return water temperature is small in each layer, and system cannot guarantee a low flow rate, it will result in thermal comfort reduction and insufficient heating load. Therefore the on-off time and area method heat metering system is generally used in the 6-storey building and less 6-storey building, or put high-rise building into two/three parts and independent heating system a re provided in each part.

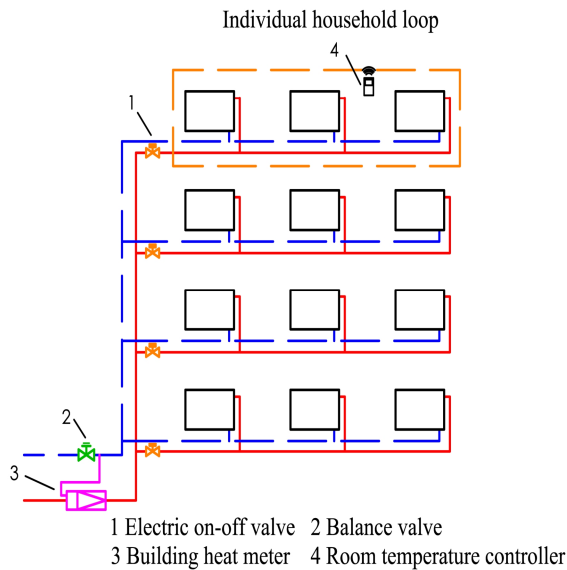


Fig. 3 Vertical double-pipe system

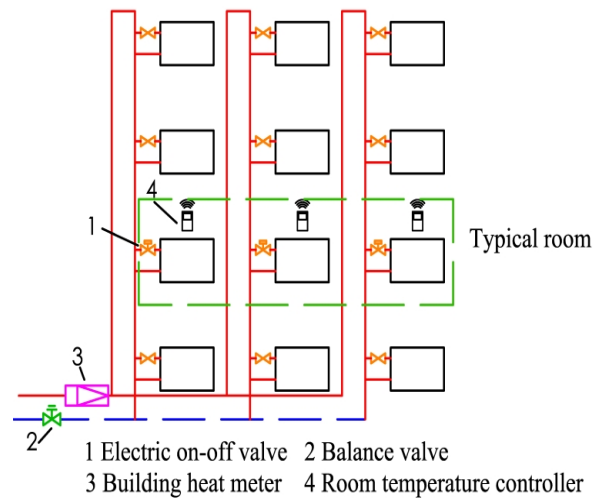


Fig. 4 Vertical single crossover-pipe heating system

Energy-saving effect in a practical engineering

Application on-off time area method of measuring heating technology that allows heat source heating system heating demand, improve the energy efficiency of the heating system, reducing energy waste, reached the energy saving effect. Take residential building in Beijing as example, the heating area of building about 3396m². Building heating system uses double-pipes hot-water system. Design water supply temperature is 75℃, and return water temperature is 60℃. Heat metering system uses on-off time and area method. Figure 5 illustrates the room temperature of each different layers and orientation test room which someone in. It can be seen from the figure 5, in building which use the on-off time and area method heat metering system, indoor temperature meet Beijing heating standard requirement.

By testing the supply water temperature, return water temperature and flow rate, building heating heat consumption is 1078.92GJ, and heat consumption per unit area is 0.27GJ/m². Compare with other similar building which not uses the on-off time and area method, heating energy saving rate is 22.8%.

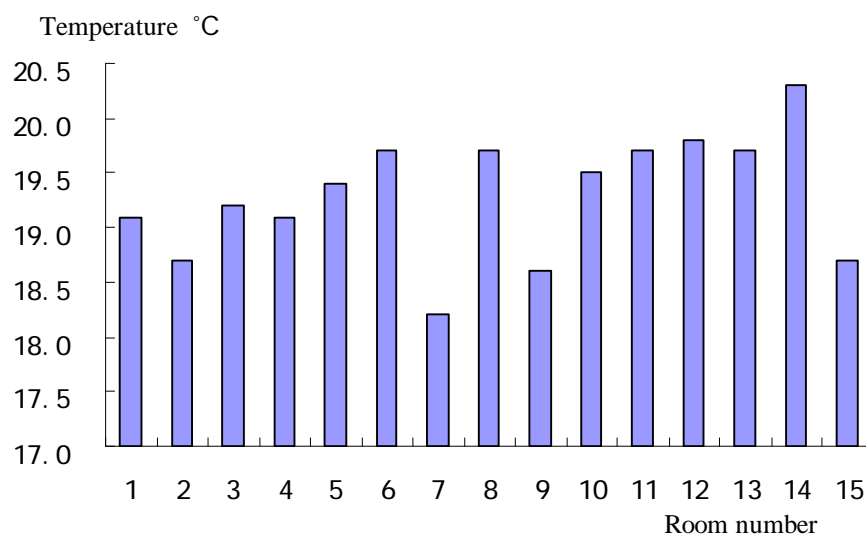


Fig.5 Heating system indoor temperature

Summary

With on-off time area method heat metering technology, user's heating load according to user's heating demand to improve the efficiency of heating system, save energy.

Heat metering system is affected by multi-factor. The principle of on-off time area method heat metering technology is based on calculating the user's heating load according to room area and on-off valve opening ratio. Thus it could avoid the problem which caused by heat transfer between households.

In a practical engineering, on-off time area method heat metering was used in its heating system. The result shows that indoor temperature meet comfortable requirement and heating energy saving rate is 22.8% compare with other similar building. This system may have some problems in practical application, but it really is a great potential measurement mode.

Acknowledgement

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