# Study on the device of multipath household heat metering

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**Abstract**

One of the most important contents of reforming heating system is that more attention will be paid to residential energy conservation and improvement of heating facilities in order to charge heating fee by heat consumption. But the out-dated technology prohibits the widespread use of multipath household heat metering. Since the heating system in China is still confronted by the substantial energy waste, the jumble of pipelines and difficult management of the system etc, a company in Liao Ning has developed a new kind of water supply system on multipath household heat metering. The new system blazes new trails on household heat metering, solving the problem of traditional pipelines. The paper uses the computational method of hydrodynamics and provides the experimental platform of pipe resistance measurement and its theoretical parameter for the system. The study shows that resistance coefficient of the experimental pipeline corresponds with the theory, and multipath household heat metering has favourable prospects.

*Keywords:* converter multipath, household heat metering, pipe resistance measurement

## 1 Introduction

The consumption of energy resources is one of the core problems for the "Scientific Concept of Development". How to effectively save energy and reduce consumption has become an important strategic task for the future of a country. According to statistics, heating energy consumption on the building accounts for about 30% of total energy consumption of the national economy and 52% of China's total building energy. Therefore, the heating control is the biggest and most potential way of energy conservation in China, a top priority in energy-saving work. [1] Urban central heating is mainly used in the northern area of China, an important urban infrastructure meeting the requirements of basic living quality of urban residents. At present, China's heating fee is charged according to the area, traditional, unreasonable, more importantly, wasting energy; so many experts put forward the concept of household heat metering.

## 2 System introduction

Household heat metering not only saves energy, but also charges fairly and manages easily [2]. It changes the heating pipes from the initial series or parallel operation into a set of system of each family, solving the problem that now if individual users do not pay, other users would be involved in real trouble. At the same time, it truly realizes the heating commercialization since it charges by the actual use of heating instead of the housing area. In view of that, a company in Province Liaoning developed a new type of water supply system of multipath household heat metering. The centralized control of the household heat metering spreads among seven floors, and it is shown in Figure 1. For the system, porous pipes and accessories of pipelines are mainly made of polyvinyl chloride resin (PVC-U) and polypropylene (PP-R) respectively, lastly centralized control system on water supply system of the household metering comes into being. Floor one and floor two share pipes with seven channels, and the interior of the pipe is divided evenly into small seven fan-shaped paths, which correspondingly suply one house. And water separator with seven holes turns into those with five holes between the second and third floor, so floor three and floor four use pipes with five channels. In Figure 2, since the interior of the pipe was divided into small five fan-shaped paths, water separator with five holes turns into those with three holes between floor four and floor five. So pipes with three channels are used between floor five and floor six, and between floor six and floor seven is three steering connector. The pipes between the floors uses flange to connect together, sealed by the sealing rubber ring. This system adopts mechanical circulatory system of single up-supply and down-circle pipe in practice, and the main water supply pipe for heating reaches the top of floor seven. Put the main water supply pipe and water separator of seven holes together and meanwhile water separator of seven holes connect pipes of seven channels through output of seven paths. Heating each floor, output of one path among output of seven hot water paths connects with heating equipment, and blocking pad with seven channels will seal firmly the hole of the bottom, so this part becomes empty, preparing backwater of heating for the user. The heating backwater of floor seven is directed into the original pipes of seven empty holes, finally achieving a heating return around floor seven. By this way, the heating shunt realizes household heating of floor seven to floor one by different paths. Completing the seven loop heating, the system extends to the underground and then into heating well or heating box through right-angle connector of seven holes, so in such condition is heating

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system of household metering developed through multi-channel self circulation. It charges heating fee by central heating metering, suitable for every house of new buildings, and also applicable to reconstruction of the old building. There is profound basis for heating household metering. Central heating, the infrastructure of the city, saves energy and reduces environment pollution, improving people's quality of life, and so on.

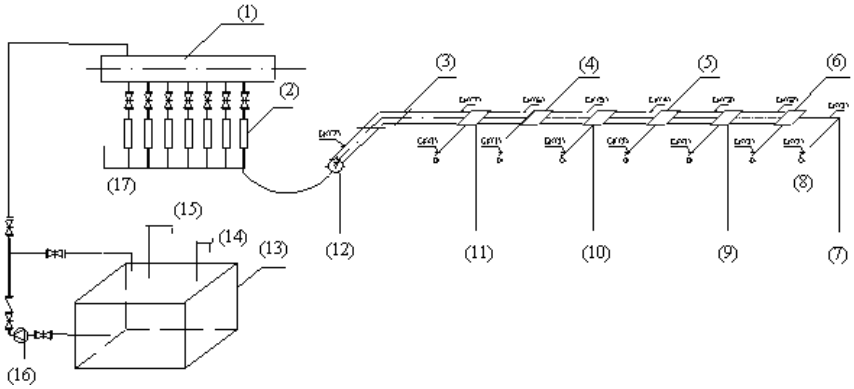


FIGURE 1 Centralized control system on water supply system of the household metering

(1) water separator (2) flow meter (3) right-angle connector of seven holes (4) water separator with five holes changed from those with seven holes

(5) water separator with three holes changed from those with five holes (6) head cover of three channels (7) 20 connectors (8) connecting with the water tank

(9) water separator with three holes (10) water separator with five holes (11) water separator with seven holes (12) merging device of seven holes

(13) water tank (14) connecting circulation of the sink (15) water replenishing (16) water pump (17) merging device

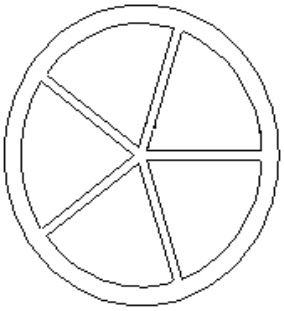

FIGURE 2 The diagram of the pipe with five channels

## 3 Calculation on heat transfer between different pipes

Now China is gradually charging fees by household metering of central heating. On the one hand, the method saves energy; on the other hand, it brings a lot of trouble. First, different users are located in the different places of the buildings, so each room has different face with various external and internal walls, and each user has different heating load caused by different circumstances of transferring the heat. Secondly, when temperature of one room is higher than its adjacent room, the room would transfer heat to the adjacent room, increasing heat load of the other room and meanwhile users do not need genuinely this part of increased load. Although this system is newly developed, there still exist some problems, such as heat transferring between the pipes. Take the pipe of seven channels as an example, temperature of indoor water is 85°C and backwater temperature 60°C in this system. Since the water still goes back to the duct, six hot channels and one cold path appear among the pipes of floor six (it is only relatively said that 85°C is hot, 60°C cold), and in the pipes of five floor occur five hot channels and two cold, and so on. Therefore, we carried out the calculation and measurement, thermal conductivity of PVC tube was 0.16w/m2 K, return pipe of the heating system in floor seven have six hot channels and one cold, and that of floor six five, hot channels and two cold.

Return pipe of the second floor is six cold channels and one hot, so conductive heating during the passage between the return water in the second floor to inlet supply pipe in the first floor accounts for the largest amount of heat conduction, and heat conduction is:

$$q = \frac{\Delta t}{\delta} = 666.67 w / m^2 . \quad (1)$$

The most unfavourable heat loss:

$$Q = 2.5 \times 0.25 \times q = 416.66875 w . \quad (2)$$

Heat loss rate:

$$416.66875/7200=5.787\%. \quad (3)$$

Heat transfer in every hole does exist, and the heat loss accounts for about 6% of total calories. To meet the needs

of users, the provision in calculation of the heating is that calculation of heat load increase to 6%-10%. Although this only takes pipes of seven channels as an example, in other cases, the heat loss and the heat load of the room is not different for the same housing.

## 4 The principle of resistance measurement

Since water resistance in multipath household metering has both pipe frictional drag and local resistance, while measuring the resistance, pipes with seven channels, those of five paths, those of three channels or their accessories are respectively supposed to measure both frictional drag and local resistance.

### 4.1 A SUBSECTION THE PRINCIPLE OF PIPE FRICIONAL DRAG

According to Bernoulli equation [4]

$$z_1+\frac{p_1}{\gamma}+\frac{v_1}{2g}=z_2+\frac{p_2}{\gamma}+\frac{v_2}{2g}+h_f. \tag{4}$$

By continuity Equation, when the diameter is constant, flow velocity is [5]

$$v_1=v_2=v=\frac{Q}{A}, \tag{5}$$

frictional resistance is [6]

$$h_f=(z_1+\frac{p_1}{\gamma})-(z_2+\frac{p_2}{\gamma}). \tag{6}$$

Then by the Equation, [7]

$$h_f=\lambda\cdot\frac{l}{d_e}\cdot\frac{v^2}{2g}. \tag{7}$$

friction coefficient $\lambda$ can be calculated, meanwhile, also according to the Equation [8]

$$R_e=\frac{vd_e}{v}. \tag{8}$$

Reynolds number $R_e$ is obtained and the diagram $R_e-\lambda$ with different Reynolds numbers drawn.

### 4.2 THE DETERMINATION PRINCIPLE OF LOCAL RESISTANCE

From the Equation

$$h_\xi=\xi\frac{v^2}{2g}, \tag{9}$$

$$\xi=\frac{2gh_\xi}{v^2} \tag{10}$$

is available.

Then the measurement of local resistance loss can be read by the piezometric tube, that is, the actual local resistance loss should be equal to the measurement of the local resistance loss minus loss of the two measurement points along the path.

## 5 The result of measurement

According to requirements of actual heating velocity, design velocity for the experimental pipeline is 0.8~1.2m/s and the corresponding Reynolds number about 14500~21000. In this range, regardless pipes with seven channels, those of five channels or those of three channels, the corresponding region in diagram Mo Di are smooth region of turbulent flow and transitional rough area of turbulent flow. Roughness of the pipe has been determined (about 0.0008 mm), so the curve $\mathrm{Re}-\lambda$ presents the downtrend. By using the method of curve regression, the paper shows the working system under the non-design condition. Figure 3 is a diagram $\mathrm{Re}-\lambda$ of pipes with seven channels.

In order to verify accuracy of the experimental results, in the same diagram can be drawn and compared theoretical curve of the regression for pipes with seven channels, those of five paths, those of three channels and cast iron pipe with the same roughness, as is shown in Figure 4. In Table 1 is local resistance coefficient.

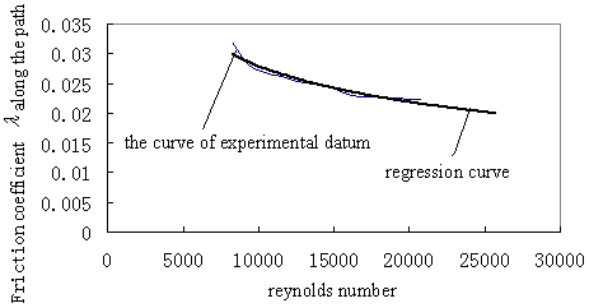


FIGURE 3 The diagram of pipes with seven channels

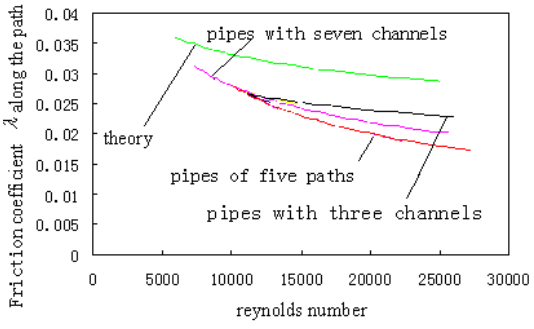


FIGURE 4 Regression curve $\mathrm{Re}-\lambda$

TABLE 1 The local resistance coefficient

| Project | system of floor7 | system of floor6 | system of loor5 | system of loor4 | system of loor3 | system of loor2 | system of loor1 |
|---|---|---|---|---|---|---|---|
| resistance coefficient of merging device of seven holes | | | | | | | 1.54363 |
| resistance coefficient of connector of seven holes | 0.949072 | 1.700191 | 1.09999 | 1.41039 | 1.16111 | 1.88151 | 1.35818 |
| resistance coefficient of water separator with seven holes | 1.037447 | 1.127317 | 1.61171 | 1.06657 | 1.82916 | 1.56194 | 1.65768 |
| resistance coefficient of water separator with five holes changed by those with seven holes | 1.271711 | 1.226959 | 1.33825 | 1.16806 | 1.85618 | 1.72526 | |
| resistance coefficient of water separator with five holes | 1.569386 | 1.11457 | 1.1921 | 1.06456 | 1.88297 | | |
| resistance coefficient of water separator with three holes changed by those with five holes | 1.496716 | 1.634158 | 1.49962 | 1.61476 | | | |
| resistance coefficient of water separator with three holes | 1.147256 | 1.511206 | 1.48419 | | | | |
| resistance coefficient of head cover of three channels | 0.798686 | 4.812194 | | | | | |
| 20 connectors | 0.441452 | | | | | | |
| mat of seven apertures | | | | | | | 1.03224 |
| mat of seven apertures | | | | | | | 0.72685 |
| mat of three apertures | | | | | | | 1.35128 |

## 6 Conclusion

Seen from Figure 3, resistance coefficient of pipes with three channels is biggest, followed by that of pipes with seven channels, then is that of pipes with five channels, and resistance coefficient of cast iron pipe with the same roughness is obviously higher than the other three pipelines. For pipes with seven channels, those with five paths and those with three paths, is the same the friction coefficient of Reynolds number before about 11000, which is located in the smooth region of turbulent flow. Afterwards, is different the roughness of each kind of pipe, and so the turbulent transition region appears, which correspond to actual situation very well.

Error of friction coefficient is smaller, because there is no "instability" in the experimental process, and the graph $R_e - \lambda$ and theory also match very well, so the results can be directly applied to engineering practice. But the local resistance coefficient has relatively poor reliability, there are several reasons:

1) Unavoidable errors read by the man.

2) For flange mat of seven apertures, that of five apertures and that of three apertures, deformation exits greatly. When installing the system, tightening bolts leads directly to the flange deformation. Then large deformation appears in the channels, which deviates directly the test result of the local resistance coefficient greatly from the actual results. This is the reason why only water separator with seven channels on floor one is much higher than that of the other floors.

3) Do house-installed pipe, water separator with five holes changed by those with seven holes, water separator with three holes changed by those with five holes and head cover of three channels fuse poorly. The main problem is that house-installed pipe is not in the same height as the central line of the system, and there exits an angel, which directly causes the local loss of this place.

4) Water pump work longer, water tank is smaller, and the cooling effect is relatively not good. Consequently vapor contained in the water increases and easily collects in the plastic hose connecting with piezometric tube, which leads the water column astray.

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