Hot Water Heating System Operation and Energy Conservation

Zongyi Shao Hongbing Chen Ping Wei

Key Lab of HVAC
Beijing Institute of Civil Engineering and Architecture
Beijing, China

Hebei Engineering and Technical College
Cangzhou, China

shaozongyi@sina.com.cn behbchen@126.com weiping_126@126.com

Abstract: Based on an example of the reconstruction of a hot water heating system, this paper provides an analysis and comparison of the operations of hot water heating systems, including supply water temperature adjustment, flow adjustment during each heating period, and temperature-flow adjustment with frequency control. The study shows the most energy efficient operating method is a variable flow heating system, which should be popularized to the heating field.

Keywords: adjustment, operating way, energy conservation

1. INTRODUCTION

Since North China has a long heating season, the electricity consumption of heating system is very huge. But for traditional heating system, fixed flow rate is involved leading to large electricity consumption and bad adjustment of heat network. Therefore, it is necessary to study the water circulation of heating system.

2. SPEED CONTROLLED PUMP TECHNOLOGY [1]

The circulating mode of heating system includes fixed flow rate and variable flow rate. The selection of pump for the two circulating modes is different. For the former, the circulating pump is selected according to system flow rate. Generally one is for use and one standby or two for use one standby. The flow rate of circulating pump should be 1.1~1.2 times as the theoretical flow rate of network, and the head should be 1.05~1.10 times as the total pipe resistance. As for variable flow rate heating system, the pumps are equipped in three stages. The flow rates are 100%, 80% and 60% respectively and the heads are 100%, 64%, and 36% respectively. Then the pump powers are 100%, 51% and 22% respectively. For small heating system, the pumps may be equipped in two stages. The flow rates are 100% and 75%, and the heads are 100% and 51%, then the pump powers are 100% and 42%. From the above analysis we can find the circulating mode of variable flow rate can reduce electricity consumption of heating system. In recent years, with the development of frequency converted technology, it is easier to achieve the adjustment of flow rate for heating system. Since the cost of frequency converted equipments reduces, more and more heating system would use variable flow rate heating system.

The Energy Efficient Design Standard for Residential Buildings says the electricity consumption of circulating pumps should be controlled at the range of 0.35～0.45W/m^2, but it is about 0.6～0.9 W/m^2 in reality. Frequency converted technology may reduce the electricity consumption to a reasonable range.

The relationship between flow rate, head, power and pump impeller speed is shown in the following formula.

$$\frac{G}{G_m} = (\frac{H}{H_M})^{\frac{1}{2}} = (\frac{N}{N_m})^{\frac{1}{3}} = \frac{n}{n_m} \qquad (1)$$

From Fig.1 we can see that the head is directly proportional with the square of flow rate, and the power is directly proportional with the cube of flow rate. When the flow rate reduces by 20%, the impeller speed would reduce by 20%, and the electricity consumption would accordingly reduce by 50%. When the flow rate reduces by 50%, the impeller speed would reduce by 50%, and the electricity consumption would accordingly reduce by 87.5%.

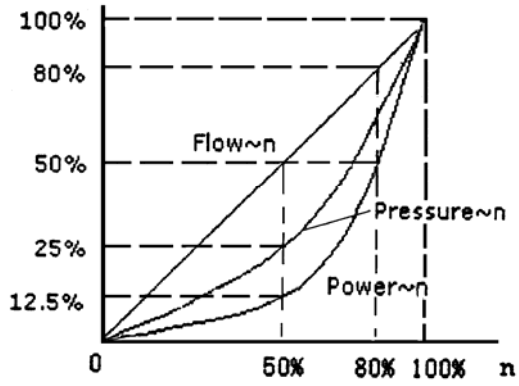

Fig.1: The relationship between flow rate, head and power of pump

Based on the figure of the characteristic curves of ISB200 / 150400-50A pump under standard rotate speed of 1450rpm, we drew the curves under 1450rpm, 850rpm and 550rpm showing the relationships between flow rate and head and between flow rate and power (shown in Fig.2 and 3).

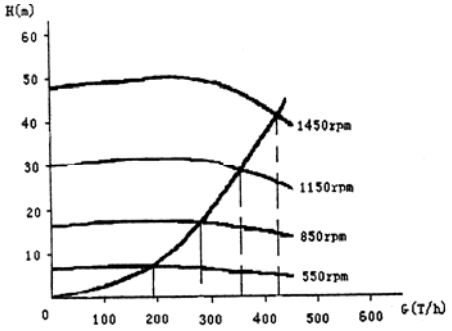

Fig.2 The relationship between flow rate and head (ISB200 / 150-400-50A pump)

From the above figures we can find that the change of impeller speed has a great impact on the flow rate, head and power. It is the frequency converted technology that makes it possible to adjust the flow rate and head, and to lead to electricity savings.

At present, the adjustment of the flow rate of heating system includes two measures. The first is to adjust the opening degree of valves, and the second is to add a frequency converter to circulating pump [2].

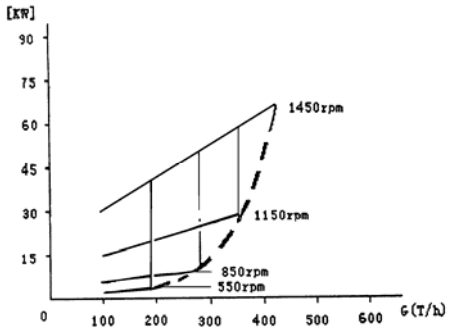

Fig.3 The relationship between flow rate and power (ISB200 / 150-400-50A pump)

3. APPLICATIONS

A heating system of a residential area in Beijing is taken for an example.

The residential area has a heated area of 298000m2 for phase one, and 60000m2 for phase two. A huge boiler house with indirect connection is involved in the heating system. The primary water temperature is 120℃/70℃, and the secondary water temperature is 95℃/70℃. The heat source has been installed with a computer monitoring system and 3 ISB200 / 150-400-50A pumps, one is for use two standby. According to the design flow rate of the primary network, only one pump would be needed to meet the demand on common use. According to the situation of outdoor weather for 1998~1999 and 1999~2000 heating seasons, the statistics of the distribution of heating load for the heating system is performed, and the result shows it is basically the same. Flow rate adjustment is involved for the primary network of heating system under different heating loads, and the operating period time under different flow rate is shown in Table 1 [3].

From table 1 we can see that the primary network of heating system mostly operates under the flow rates of 150t/h and 300t/h, about 700 hours respectively. The operating time under the flow rate of 100t/h and 400t/h is about 80 hours respectively. Therefore, the heating system is in operation under part heating load in most times. Speed controlled pump can optimize the operation of heating system under part heating load. Table 1 provides an analysis on the electricity consumption of heating system under the different adjustment of flow rate by valves

and speed controlled pumps. The data is obtained based on Fig.2.

Tab. 1 Analysis on the electricity consumption with the flow rate of primary network adjusted by valves and speed controlled pumps

Flow rate (t/h)	The distribution of operating time under different flow rate		Adjustment by valves		Adjustment by speed controlled pump	
	Percent (%)	Operating time (h)	Power (kw)	Electricity consumption (kwh)	Power (kw)	Electricity consumption (kwh)
150	26	700	35	24,500	2.6	1,820
200	14	360	40	14,400	8.0	2.880
250	18	480	46.6	22,368	9.0	4,320
300	26	700	52.5	36,750	26.2	18,340
350	13	360	58.0	20,880	29.6	10,656
400	3	80	62.8	5,024	62.8	5,024
Total	100	2680		123,922		43,040

If supply temperature control is involved for the primary network of heating system, the flow rate would be 400m^3/h, and the power would be 62.8 kW. Since the annual average operating time of 1998~1999 and 1999~2000 heating seasons is 2680 hours, the electricity consumption will be 168,304kWh.

If the electricity price is 0.8 RMB/kWh, the operating cost of circulation pumps of the primary network would be:

Supply temperature adjustment

168,304*0.8=135,000 RMB

Flow rate adjustment by valves:

123,922*0.8=99,000 RMB

Flow rate adjustment by speed controlled pumps:

43,040*0.8=34,000 RMB

From the above analysis we can find that the flow rate adjustment of the primary network by speed controlled pumps can lead to electricity savings of 125,264kWh per heating season, i.e. 100,000 RMB. The savings is 80,882kWh more than that of flow rate adjustment by valves, and the operating cost is 65,000 RMB lower accordingly.

The investment of the two frequency controlled equipments for circulating pumps is about 135,000 RMB, and the pay-back period time would be less than 2 years since the operating cost of circulating pumps reduces 100,000 RMB per year.

4. CONCLUSIONS

At present, single supply temperature adjustment is involved for most heating sources. However, the flow rate adjustment by speed controlled pumps can lead to a large amount of electricity savings and the reduction of operating cost, which will also release the situation of power supply and improve the economic performance of heating. With the development of scientific technology, the frequency converted technology will become more and more mature, and the price will also become lower and lower, which lead to a bright future.

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