

Research on Energy-saving Evaluation Index System for Heating Network

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Abstract. By actual testing of the first network system of a company in Changchun City, the main energy consumption aspects were analysed and calculated, then the determination of energy-saving evaluation indexes was discussed. Based on the properties of indexes, the energy-saving evaluation index framework was provided and scoring method was introduced in detail.

Introduction

With the increasingly expansion of urbanization, heating area of urban is increasing year by year. According to some statistics, China floor area increasing by average 20 calculate square meters every year[1]. Up to 2012, central heating area of China was 51.8 calculate square meters, and the heating pipe length was 160000 km[2]. Although our central heating industry has got great development over the past 30 years, but low heating energy efficiency still limits the development of urban heating systems, and the heat loss is the main cause of the energy waste. In China, outdoor network heating transport efficiency is about 70%, which is much less than 92%~95% level of foreign. So the energy-saving evaluation of heating network system has important real implications.

Determination of energy-saving evaluation indexes

For heating network system, the selection of energy-saving evaluation indexes have direct effect on the reasonableness of the evaluation system, so, based on actual test of a company in Changchun City in 2014-2015 heating season and the *Evaluation Standard for District Heating System GB/T50627-2010*, the author confirm energy-saving evaluation indexes of network system.

Hydraulic balance level

In central heating system, when the whole system of circulating water meet the design conditions, the hydraulic balance level refers the ratio of design and test circulating water of branch or end line[3]. Thermal network hydraulic balance is very important for well-proportioned heating and energy-saving operation[4], The calculation formula shows as follow:

$$HB_c = \frac{G_c}{G_s} \quad (1)$$

Specifically:

HB_c —Hydraulic balance level;

G_s —Design circulating water (m^3/s);

G_c —Test circulating water (m^3/s).

According to test datas and the calculation formula showing above, the hydraulic balance level distribution of the company substations shown in figure 1, for heating network system, the standard value of the hydraulic balance level is 0.9~1.2, as dotted line shown in figure 1.

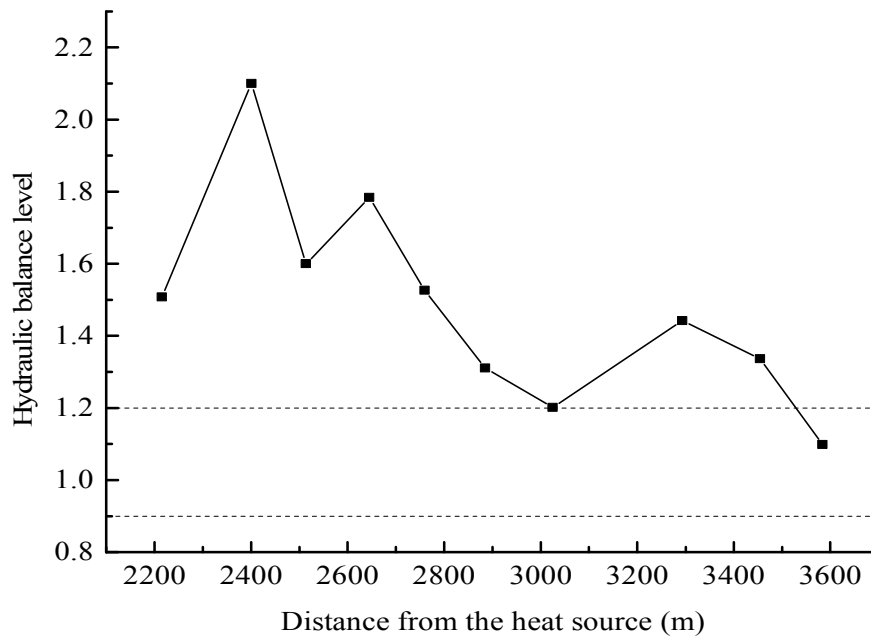


Fig.1 Hydraulic balance level distribution of a company substations

It can be shown in figure 1, the variation trend of hydraulic balance level decrease as the distance between the heat source and substation increase, there are only two meet requirement among the ten tested substations. This proves that, for central heating system, the problem of hydraulic balance is serious, so the hydraulic balance level should be one of the important indexes of energy-saving evaluation system.

Filling water ratio

The value of filling water ratio responses the splitting of the network system, which result not only energy waste but also adverse effects on heating quality. The calculation formula shows as follow:

$$g_c = \frac{G_{cb}}{G_s} \quad (2)$$

Specifically:

g_c —The filling water ratio;

G_s —Design circulating water (m^3/s);

G_{cb} —Test filling water (m^3/s).

Heating transport efficiency

Heating transport efficiency responses the effective utilization degree of energy, at the same time, it also responses pipe insulation condition. The calculation formula shows as follow:

$$\eta_{sc} = \frac{\sum Q_{yh}}{\sum Q_{ry}} \times 100\% \quad (3)$$

Specifically:

η_{sc} —The heating transport efficiency;

Q_{yh} —Heat consumption of users (MJ);

Q_{ry} —Heat supply from heat source (MJ).

In order to shown the effect of filling water ratio and heating transport efficiency on heating network, through the relevant statistical analysis found that the relationship shown in Figure 2.

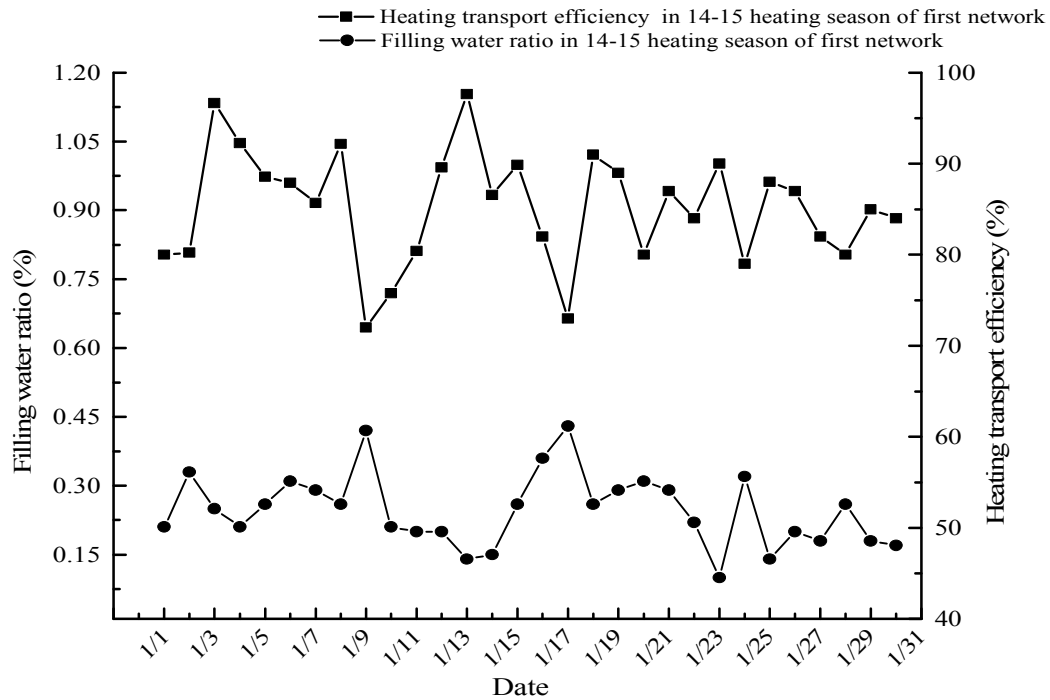


Fig.2 Relationship of filling water ratio and heating transport efficiency

As shown in the figure 2, there is a strong correlation between filling water ratio and heating transport efficiency. The results showed that the heating transport efficiency decreased with the increased of filling water ratio, that is the two change in the opposite trend. So they are important for energy-saving of the heating network.

HER

HER refers the ratio of electricity consumption to transferred heat quantity, evaluating the rationality of electricity consumption and selection of pump[5].Based on *Design standard for energy efficiency of residential buildings in severe cold and cold zones*, The calculation formula shows as follow:

$$EHR = \frac{N}{Q \times \eta} \leq \frac{A \times (20.4 + \alpha \sum L)}{\Delta t} \quad (4)$$

Specifically:

N —Shaft power of designed condition (kw);

Q —Heating load of building (kw);

η —Summation of motor efficiency and transmission efficiency ;

A —Coefficient connection with heating load;

Δt —Supply and return water temperature difference (°C);

$\sum L$ —The total length of heating pipe between heat source generator room and end user of index circuit (include supply and return water pipe) (m); $\sum L \leq 400\text{m}$, $\alpha = 0.0115$; $400\text{m} < \sum L < 1000\text{m}$, $\alpha = 0.003833 + 3.067 / \sum L$; $\sum L \geq 1000\text{m}$, $\alpha = 0.0069$.

Pump operation efficiency

The operation efficiency reflects the consumption of electric energy, but in fact most of pumps were work in low load condition, which can be seen from the test data. Unquestionable, it should be involved in the evaluation index system. The calculation formula shows as follow:

$$\eta_s = \frac{G_{sc}}{G_{ed}} \quad (5)$$

Specifically:

η_s —Pump operation efficiency;

G_{sc} —Test flow of pump (m³/h);

G_{ed} —Rated flow of pump (m³/h).

Evaluation index framework

Based on the properties of evaluation index, this paper divide the evaluation index system into two layers by AHP (Analytic Hierarchy Process), which is shown in Figure 3.

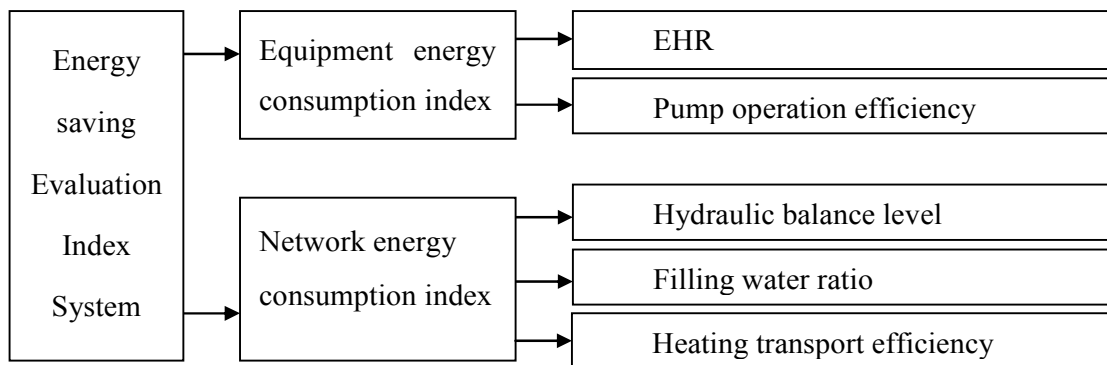


Fig.3 Evaluation index framework of heating network

Weight of evaluation indexes

It can be seen through the above calculation and analysis, in order to make sure the importance of indexes in the evaluation system, the author send questionnaires to experts, university professors, designers and first-tier workers, then on this basis, applying specialist making method to ensure the weight of evaluation index, which is shown in table 1.

Table 1 weight of evaluation index	
Indexes	Weight
Hydraulic balance level	0.3
Filling water ratio	0.25
Heating transport efficiency	0.25
Pump operation efficiency	0.1
EHR	0.1

Scoring method of system

Based on related design standard for energy efficiency, code for quality acceptance and design code, the author divided every index into three grades, that is 0, 5, 10. Specific method is shown as table 2.

Table 2 Scoring method of evaluation index for heating network system

Index	Standard		Score	Weight
HB_c	$0.9 \leq HB_c \leq 1.2$		10	0.3
	$0.8 \leq HB_c < 0.9$ or $1.2 < HB_c \leq 1.3$		5	
	$HB_c < 0.8$ or $HB_c > 1.3$		0	
g_c	First network	$g_c \leq 0.5\%$	10	0.25
		$0.5\% < g_c \leq 0.7\%$	5	
		$g_c > 0.7$	0	
	Second network	$g_c \leq 1.0\%$	10	0.25
		$1.0\% < g_c \leq 1.2\%$	5	
		$g_c > 1.2\%$	0	
η_{sc}	$\eta_{sc} \geq 90\%$		10	0.25
	$80\% \leq \eta_{sc} < 90\%$		5	
	$\eta_{sc} < 80\%$		0	
η	$\eta \geq 80\%$		10	0.1
	$65\% \leq \eta < 80\%$		5	
	$\eta_{sc} < 65\%$		0	
EHR_{cd}	$EHR_{cd} \leq EHR$		10	0.1
	$HER < EHR_{cd} \leq 1.2EHR$		5	
	$EHR_{cd} > 1.2EHR$		0	

Combined with the scoring method, the weighted scores of network system can be calculated and the star-grade can be rated by Table 2 and Table 3.

Table 2 First and second network star-grade table

Weighted score (T)	Star-grade
$T \geq 9$	Four star
$7 \leq T < 9$	Three star
$5 \leq T < 7$	Two star
$T < 5$	One star

Table 3 Heating network star-grade table

Weighted score (T)	Star-grade
$T \geq 18$	Four star
$15 \leq T < 18$	Three star
$10 \leq T < 15$	Two star
$T < 10$	One star

It's need to note that, this energy-saving evaluation index system of heating network can be used to first network, second network and the whole network. For the whole network, the first and second network should be scored respectively and the sum of each other is the final score, then the star-grade can be rated by Table 3.

Conclusions

- (1) The logical choice of evaluation indexes for heating network system is very important. Because of large-scale and the complexity, in order to construct the simple and effective evaluation system, from key energy consumption links to start is necessary.
- (2) Based on the structure features of network system, the applicability is significant. In this paper, the evaluation system is appropriate for the first, the second and the whole heating network.

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