ANALYSIS ON THE TECHNIQUE AND ECONOMICS OF LOW TEMPERATURE GEOTHERMAL SPACE HEATING BY HEAT PUMP

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ABSTRACT

This paper explores the technique and economics of 45–60 "C low temperature geothermal space heating by heat pumps Taking the national conditions of China into account, emphasis is on the analysis of the economics, energy saving effect and environmental protection of low temperature geothermal space heating by heat pumps on two types of heating terminals radiator and fan coil

INTRODUCTION

At present, it's quite common that the discharged water temperature of most geothermal space heating systems in China is higher than 45 °C, some even reaching 60 °C If we can not make use of this energy effectively, energy waste and pollution will result Before the low temperature heat source can be utilized for space heating, the analysis on the technique and economics feasibility of space heating is required It's also necessary to compare the geothermal space heating system with conventional boiler heating system

THE EVALUATION METHOD OF TECHNIQUE AND ECONOMICS FOR LOW TEMPERATURE GEOTHERMAL SPACE HEATING SYSTEM

The capital cost of geothermal space heating system is very high. and the technical and economical parameters vary in large range so that the economics evaluation is necessary to select the suitable technical schemes for heating system, and the comparison between geothermal heating and conventional heating system is also necessary.

The main purpose of technical and economics evaluation is to choose the technical schemes with the reasonable economy or to explore the technical range of reasonable economical schemes Therefore, whether or not the evaluation methods of technique and economics are correct will have direct influence on the scheme select, hence it's very important to choose an suitable evaluation method for geothermal space heating system.

A software called " Optimization of technique and economics of geothermal space heating systems" has been used in this paper. The main economical parameters are as follows

(I). Capital cost: it includes the capital cost of all parts of the heating system: the cost of building, purchasing equipment, installing, and others, which include the cost of design, supervise, and unforeseen cost.

(2). Total annual cost it includes all parts of operating cost, such as geothermal water, electricity and fuel; discharging exhausted water, salary of workers, cost of management, maintenance cost. and depreciation charge Among which electricity price is treated as 0 42 Yuan/kw.h, coal prices 210 Yuan/t. According as the average coal consumption of electricity supply in China is 0.427 kg/kw h, the price parities between coal and electricity is 1 4 **68**

(3). Annual expenses: Based on ref.[1], the annual expenses of a scheme can be calculation by following equation

$$AC=[\sum(I+C-Sv-W)(P/F,i,n)](A/P,i,n)$$

Where

(P/F,i,n) ---- Capital converting coefficient
(A/P,i,n) ---- Uniform series capital recovery factor
i ---- Interest rate
n ---- The number of calculation years
I ---- Capital cost
C ---- Annual operation cost, the cost deduct depreciation charge from the total annual cost
Sv ---- Salvage of capital cost at the end of the calculation years.
W ---- Floating funds at the end of the calculation years

(4) Total annual cost per area, equals to total annual cost divided by total heating area

(5) Annual expenses per area, equals to annual expenses divided by total heating area

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In this paper, the discharged water of geothermal space heating system is taken as the object to be studied, and the typical parameters of discharged water are chosen as follows temperature is SO "C and flow **is** 125t/h, which can't be treated as conventional heating parameters for design, and have to be analyzed both possible technical schemes and feasibility of technique and economics for space heating

The analysis **is** on the discharged water of above geothermal heating system. The capital cost and total annual cost of geothermal well wouldn't be included in this system, because there have been considered in the above geothermal heating system.

Two types of heating terminals' radiator and fan coil will be analyzed in this paper

1 The analysis of the heating terminal of radiator
The average consumption of per square meter **is** assumed as $77W/m^2$ Three schemes of space heating system are considered, see Fig 1 (1) Geothermal heating alone, (2) Geothermal heating with peak heat source of boiler or heat

pumps, the proportion of the peak load is designed as the 50% of total heating load; (3) Heat pumps are designed as the heat source for space heating only, that the geothermal energy is taken as the heat source of the heat pumps. The three space heating schemes would be compared with the boiler heating in technique and economics. The main parameters are in table 1.

The results of table I shows that geothermal heating alone and geothermal heating with peak source of boiler heating can compete with boiler heating in economics. However the total annual cost per area of heat pumps heating alone is the highest among the three heating systems. In addition, the number of radiators in low temperature geothermal heating systems is 2 times as much as the 95°C/70°C conventional space heating system, so it would be difficult to be designed and decorated in the build designing and constructing, the author deem that the space heating system of low temperature geothermal with terminal of radiator is not competitive in the technical and economics aspects in China.

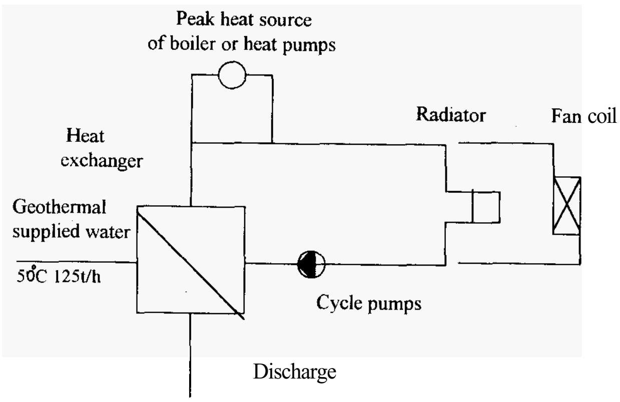

Fig 1. Schematic diagram of space heating system of geothermal as basic heat source

2. The analysis of the heating terminal of air-conditioning System.
For example: fan coil, this type of system may utilize 45 ~ 60°C heated water for space heating. The average consumption of per square meters is assumed as 93W/m^2, see Fig. 1. Geothermal energy acts as the basic heat source, the boilers or heat pumps would be chosen as the peak heat source, or heat pumps as the heating source alone. The five space heating schemes compared are as follows. Their technical and economical parameters can be calculated and analyzed. The results are shown in table 2.

Scheme 1: Geothermal heating only.
Scheme 2: Geothermal heating with peak heat source of boiler. The designed peak heat load proportion is 50%.
Scheme 3: Geothermal heating with peak heat source of heat pumps' the design peak heat load proportion is 50%.
Scheme 4: Heat pumps as heat source alone, where geothermal energy is just used as the heat source of heat pumps.
Scheme 5: Burned-coal boiler heating, no geothermal.

The results of calculations show: The total annual costs per area of scheme 1,2,3 are lower than scheme 5 of boiler, so the three schemes can be chosen to be the practical heating system. The total annual cost per area of the scheme 3, i.e., the geothermal heating system with peak heat source of heat pumps reaches only 75% of the scheme 5 of boiler, so the economic benefit of scheme 5 is competitive. Analysis of the effect factors is that the heating cost of geothermal energy as a basic heat source is only 33% of the boiler's. However The. total annual cost per area of the scheme 4, i.e , the heat pumps as heating source alone is 165% of the boiler's. to scheme 3, the total annual cost per area of heat pumps used as peak heat source amounts to 175% of the boiler heating cost as it used as peak heat source of scheme 2 It shows that heat pumps heating alone can not compete with conventional heating system at present price parities between coal and electricity for its higher value of total annual cost per area.
From another point of the energy saving effect. The amount of coal saving in geothermal heating with heat pumps is 63.73–75.7% less than that of boiler heating system. Thus the environment pollution produced by boiler burning can be reduced to a great extent, and the amount of money which is paid for curing pollution has been reduced. And also the large area which could have been occupied by boilers would been canceled by the replacement of heat pumps.

There is another benefit by applying heat pumps, the discharged water temperature of geothermal can be reduced to around 30°C. The utilization effectiveness of geothermal energy can be increased, at same time thermal pollution reduced.

THE EFFECTS OF SUPPLIED GEOTHERMAL WATER TEMPERATURE ON THE ECONOMICS OF GEOTHERMAL SPACE HEATTNG WITH HEAT PUMPS

The analysis on the economics parameters variation with the supplied temperature of geothermal water for geothermal space heating with heat pumps is given. and the air conditioning terminals is chosen as the analyzed object. At different supplied temperature 45 °C,50°C,55°Cof geothermal water, the capital cost, total annual cost per area and annual expenses per area can be calculated with the different heating area, and the comparison of economical parameters between geothermal heating and boilers can be made, see fig.2–5.

Analyzing the variation of the three main economical parameters with the heating area, we can find that the capital cost, total annual cost per area and annual expenses per area decrease with the supplied temperature of geothermal water increased, the reason is that the cost of geothermal space heating is low, further, the higher the supplied temperature of geothermal water is, the larger the heat energy of geothermal water supplied, so that the heat load of heat pumps needed is smaller, as a result, the cost by heat pumps become lower. And this result is corresponding with the conclusion above.

Comparing with the boiler heating scheme, the slope of capital cost increases with heating area for geothermal space heating with heat pumps as peak heat source is only 1/3 of boiler's. **As** to total annual cost per area and annual expenses per area, the three main economical parameters for geothermal space heating with heat pumps as peak heat source are lower than that of boilers scheme within most range of heating area, except the part of the supplied temperature of geothermal water **is** lower 45 °C, which the cost **is** higher than boiler's. This phenomena is also corresponding with the conclusion above.

Taking the economic effectiveness, energy saving and environmental protection etc. into account, the author deems that even at present price parities 1:4.68 between coal and electricity in China, the heating system with the air-conditioning heating terminal by low temperature geothermal heating with the heat pumps as peak heat source has stronger competitive ability in China.

CONCLUSIONS

1. The space heating system of low temperature geothermal with heat pumps as peak heat source has distinct effectiveness of economics, energy saving, and environmental protection comparison to conventional boilers space heating system.

2 Geothermal space heating by applying heat pumps not only improves the utilization effectiveness of geothermal energy, but also prevents the environmental pollution, and has the great sense of the urban modernization and technical progress.

3 The spread utilization of heat pumps can be obtained with the opening of coal-supply market, thus the coal price rising, and the tense situation of power supply being lightened and with the increasing requirement of environmental protection in China

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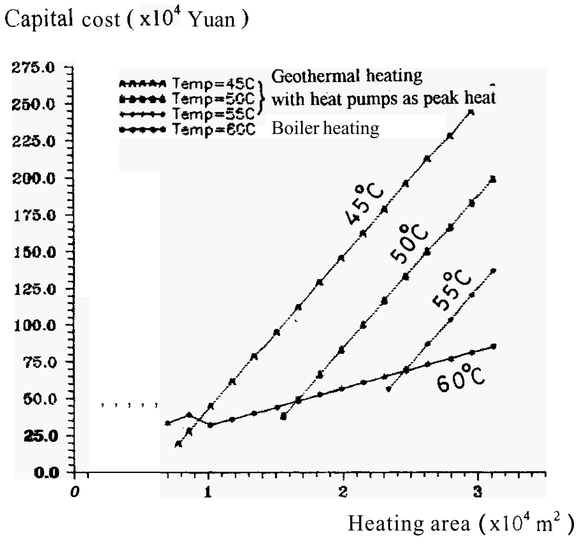

Fig.2 The relation between capital cost and heating area

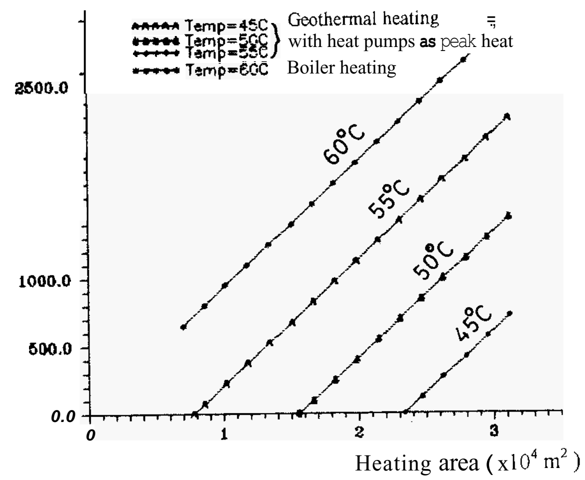

Fig.3 The relation between heat load and heating area

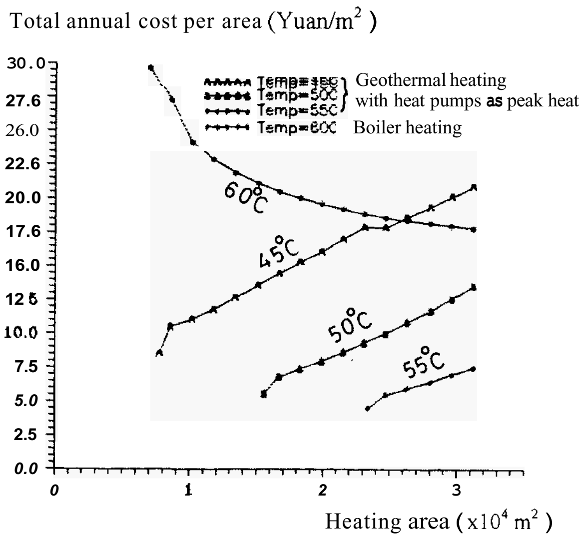

Fig 4 The relation between total annual cost and heating area

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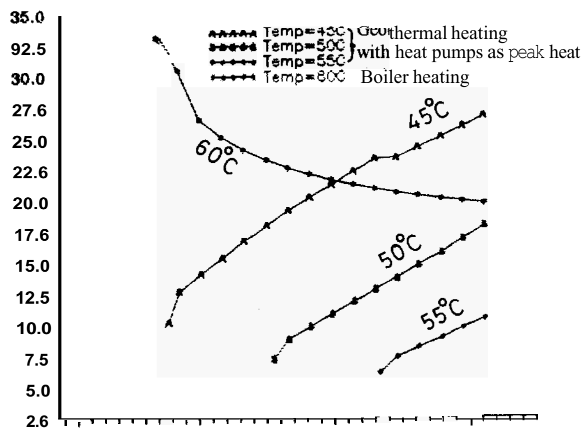

Table 1 The comparing between geothermal heating and boiler heating with the terminal of radiators

Contents \ Schemes	Geothermal heating alone	Peak heat load proportion is 50% Boiler	Heat pumps	Heat pumps heating alone	Boiler heating
Designed heat load (kw)	726.91	1453.82			
Heating area (x10^4 m^2)	0.94	1.89			
Supplied and returned water temperature (°C)	45/40	50/40	50/40	85/65	95/70
Discharged water temperature (°C)	45.00	45.00	40.83	44.43	/
The increased number of radiator	3.57	3.11	3.11	1.17	0.00
Capital cost (x10^4 Yuan)	64.69	123.55	178.76	242.65	65.28
Total annual cost per area (Yuan/m^2)	12.86	13.36	15.85	39.84	17.78
Annual expenses per area (Yuan/m^2)	17.72	18.02	22.52	50.55	20.29

Table 2. The comparing between geothermal heating and boiler heating with the terminal of fan coils

Contents \ Schemes	Scheme 1	Scheme 2	Scheme 3	Scheme 4	Scheme 5
Designed heat load (kw)	1453.82		2907.64		
Heating area (x10^4 m^2)	1.56	3.12			
Supplied and returned water temperature(°C)	45/35	53/35			
Discharged water temperature (°C)	40.00	40.00	32.34	34.24	/
The coefficient of heat pumps (COP)	/	/	4.28	4.71	/
*The quantity of coal consumption (t)	0.00	334.62	148.43	499.48	1377.03
The percent of saving coal (%)	100.00	75.70	89.22	63.73	0.00
Capital cost (x10^{4}Yuan)	38.29	79.10	195.25	324.96	85.53
Total annual cost per area (Yuan/m^2)	5.96	7.83	13.34	29.50	17.86
Annual expenses per area (Yuan/m^2)	7.70	9.65	17.72	36.78	19.87

" The quantity of coal consumption " means the quantity of coal consumption by boiler heating or equaled quantity of coal consumption by heat pumps used electricity