Research of the Domestic Solar Seasonal Storage System Based on BTES

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Abstract: Solar energy is the most clean and free energy source, solar seasonal heat storage technology can make the full use of total yearly solar radiation for building space heating demanding. First this article doing a real system that using BTES theory to confirm the design. After running 5 months, the temperature rise of the core area is almost 30℃ from both software simulation and real system. All the test data shows that solar seasonal BTES systems are possible and have a bright future.

Key words: BTES（borehole thermal energy storage）, solar energy, seasonal storage, space heating

1.Introduction

Building space heating demanding is one of the largest energy consumption in the world. In northern part of China, space heating is mainly powered by fossil fuels, especially the coals. These caused series environment pollution and poison fog or PM2.5 during winter season. So we must turn to clean energy space heating technology. Solar thermal energy is free, easy to collect, large amount and so many benefit, it's the most ideal choice. But solar thermal energy also has shortages such as bad influence by weather condition, the uncertainty of solar radiation, the unbalance during summer and winter. Usually space heating demanding gets its highest point during winter season, while the daily/monthly average solar radiation gets its lowest point; when summer time, the space heating demanding and the average solar radiation take a reverse, shown as Figure 1

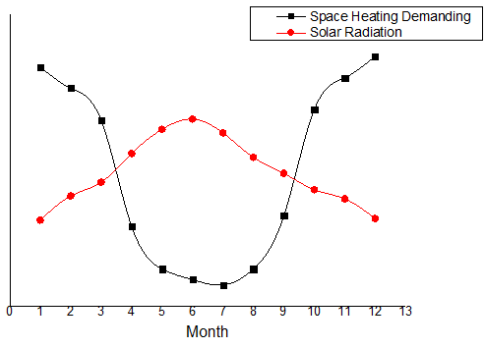

Figure.1:Average solar radiation compare with space heating demanding in a year

Using seasonal thermal storage technology can store the abundant solar energy in spring, summer and autumn, and withdraw the energy when needed in winter. The common storage medium is water. Since the space heating energy consumption is huge, when designing a solar powered space heating system, we need to use either large scale collector area or large scale storage volume. Thus we need a large plant to arrange the collectors or storage systems. Especially with the solar thermal space heating systems, if using water as storage medium, it is space costly and hard to design or build the system, etc. Using borehole thermal energy storage (BTES) system combine with solar energy is possible, it can solve problems such as unbalance between solar radiation and space heating demanding, large areas for arranging collectors and water storage systems.

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The Vartiosaari area in Finland had applied BTES with solar energy to fulfill the space heating demanding, research shown that the solar energy can cover 60% of total space heating demanding and decreased CO_2 emission by 50%, SO2 emission and dust by 70%. Another successful example is the Okotoks Town in Calgary, Canada, it also used BTES combine with solar energy to power the district heating systems, according to the running data, now it gets 100% solar fraction.

2 .Introduction for solar BTES system

Solar BTES system conclude: the collector array, energy center, borehole storage system, pipe systems and space heating endings. The energy center has buffer tank, control systems and pumps, shown as figure 2.

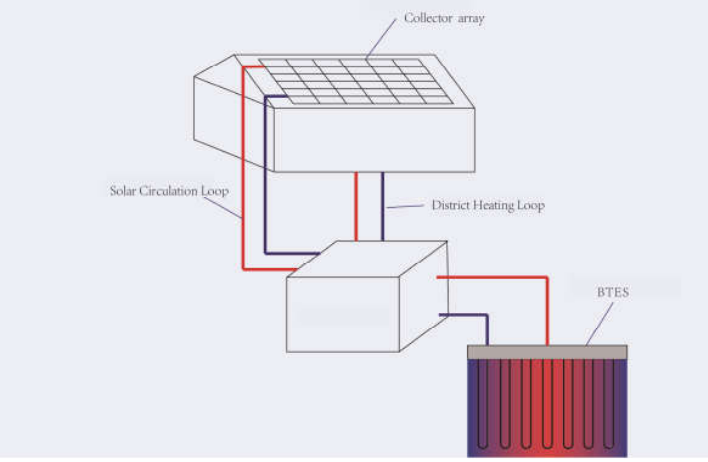

Figure.2 The schematic view of solar BTES system

During warm seasons, the solar energy gathered by collector arrays pass through the energy center and charge the BTES system, during winter season when there are space heating demanding from buildings, the energy center withdraw energy from collector arrays or discharging BTES systems. Besides, the energy can supply DHW hot water for buildings.

3 .Design analyze

The system designing parameters and system capabilities are based on software simulation, take a single house demo project located in Fangshan District, Beijing, China as example, the space heating demanding is shown in table 1.

Table.1: Space heating demanding of a single house in Beijing demo project

Parameter	**Detail value**	**Unit**
Space heating area	130	m^2
Space heating load	50	W m^{-2}
Design room temperature	18	K
Space heating days	120	Day

Based on space heating demanding, local geography condition, local weather condition, etc, the designed system schematic of solar BTES system is shown as Figure 3.

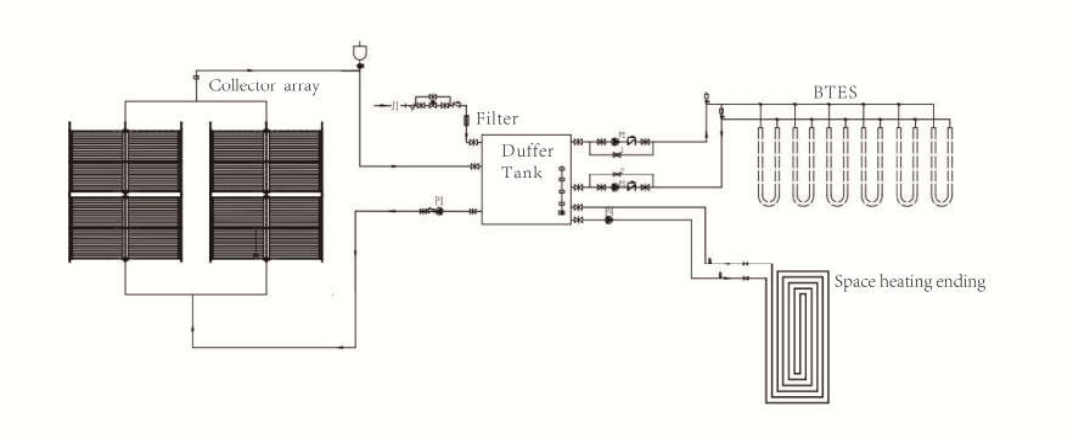

Figure .3: Schematic view of the solar BTES space heating system

The system can be putted into several parts: solar collector system, BTES system, space heating ending systems and control/monitoring system. This system can test the thermal charging characteristic for the soil storage bed in non-heating seasons. In heating seasons, when the solar energy is sufficient, the system using energy from solar collectors and buffer tank to fulfill the need; when the instant solar energy is not enough , the system use another group of pumps and valves to discharge the BTES system in reverse direction. The controlling/monitoring system can manage the system automatically and collect, storage the system data like daily average solar radiation, soil temperature at different points, heat in different parts of the system.

4 .Testing and experiment

4.1.System construction

Based on the schematic from Figure 3 and parameters from Table 1, we had finished and tested the system Final system design parameter is shown in Table 2

Table.2: System parameter

Parameter	**Detail value**	**Unit**
Solar collector area	70	m^2
Collector angle	30	^{o}
Buffer tank volume	1	m^3
BTES storage volume	381.51	m^3
Total BTES pipe length	357	m

The actual boreholes location is shown in Figure 4(Top View)

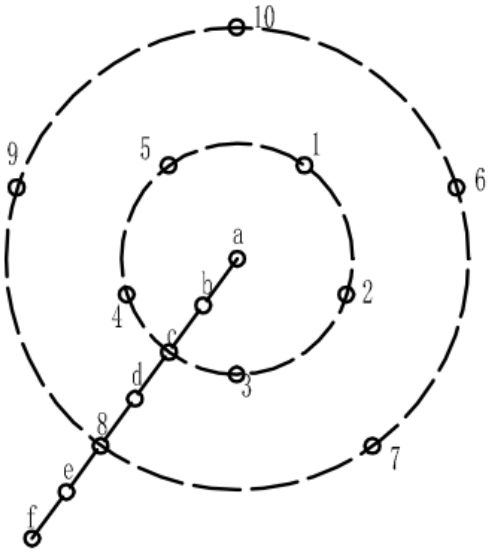

Figure.4: Distribution of the boreholes

Seen from Figure 4, Number 1~10 is the boreholes contain single U pipe, the U pipe length is 15 meters. The ten boreholes can be putted into two radius: inner radius has a diameter of 2 meters and outer radius has a diameter of 2 meters. Each radius has 5 boreholes that can exchange energy with surround soil. Number a~f are sensor holes, each has a distance of 0.5m with the last one. The vertical distribution of temperature sensors is shown in Figure 5.

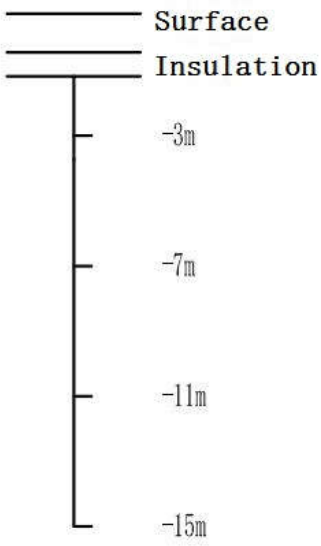

Figure.5: Vertical distribution of temperature sensors

We putted temperature sensors at -3m,-7m,-11m,-15m points inside sensor holes, combined with the horizontal sensors a~f, we could get a temperature distributing field. That's really help to analyze the temperature change.

4.2.Data Analyze

The initial temperature field is shown in Figure 6, the date is March 10th,2017.

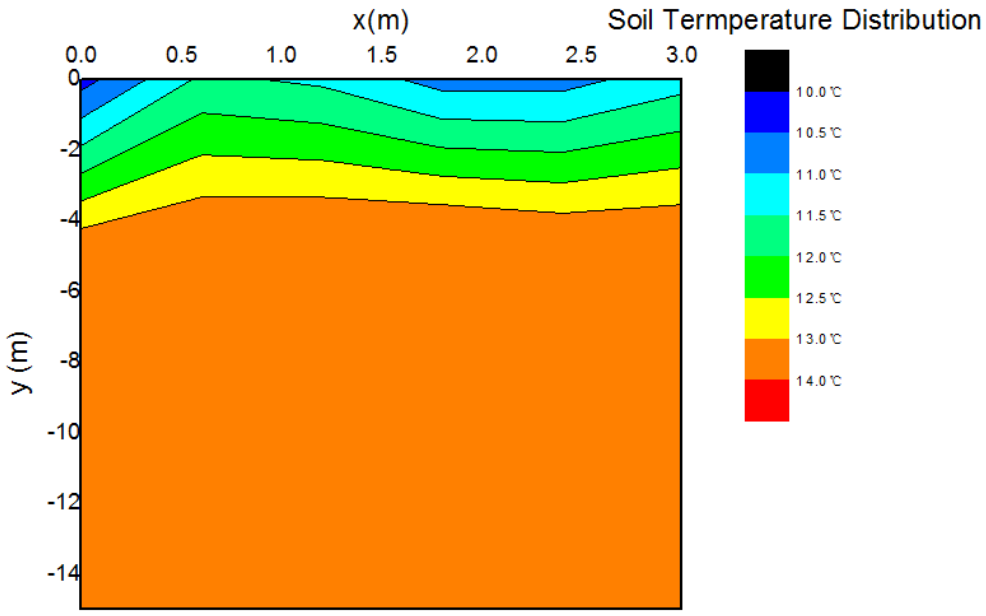

Figure.6: Initial temperature distribution of the BTES

The initial temperature is below 14 ℃.

After running 3 months, on June 1th,2017,the temperature distribution is shown in Figure 7.

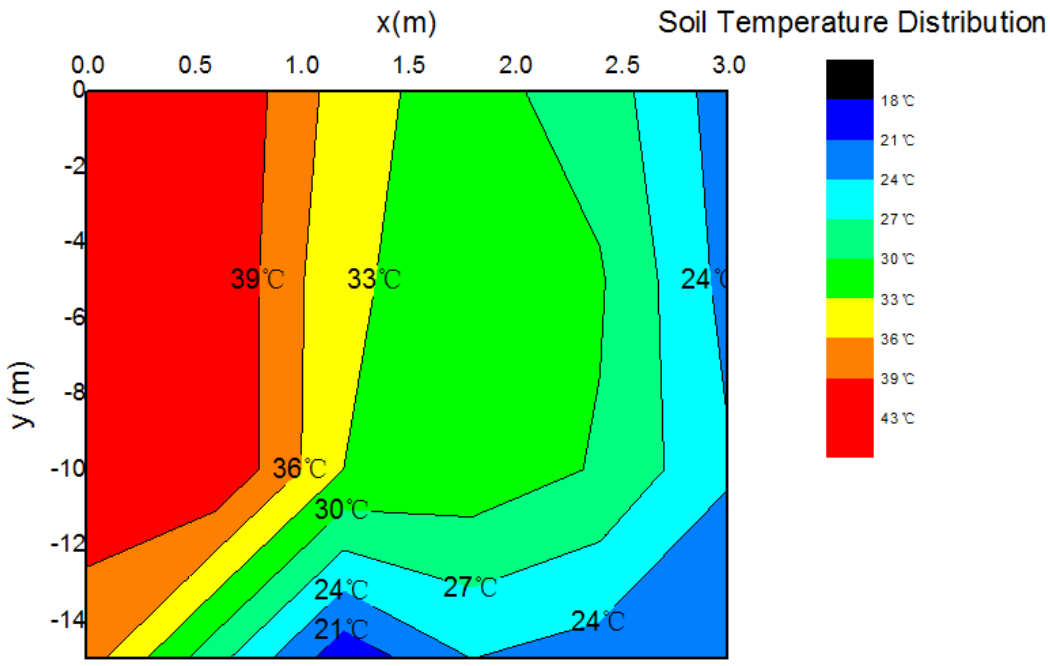

Figure.7: Temperature distribution of the BTES after 3 months

After running 3 months, the core temperature of BTES reaches over 40 ℃.

5 .Conclusion

This article is based on a real demo BTES project, after 3 months the core temperature of BTES reaches to

over 40 ℃. It shows that using soil as storage medium is possible. Although the solar fraction can increase gradually in the starting years, the solar fraction is still at low level and the system needs backup energy some time. Still a lot improvements like heat loss control, system optimize ,increase the efficiency must be done and checked. Finally, to make the solar BTES systems for commercial usage, the system costs need to be reduced and the system efficiency need to be improved.

6. Reference

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