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Research on Heat Storage Technique of Geothermal Greenhouse

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ABSTRACT

This paper describes present status of geothermal resources in Dagang district, Tianjin city, one way could improve the efficiency of geothermal utilization is especially proposed, and heat storage technique is emphasized that it is an effective approach to improve the efficiency of geothermal utilization for agricultural greenhouse. According to analyzing the structure, materials and heat preservation films of heat storage pond, concrete pond was determined finally, and tabulate PVC was covered to avoid heat loss. By means of different film experimentation to a semi-underground pond with 50 m^3 over 24 hours, the temperature of geothermal water only decreased 7ºC. It can be concluded that this kind of pond could avoid heat loss effectively and it is a good way of geothermal heat preservation. This paper could provide some valuable references for similar glass greenhouse to develop heat storage technique.

1. INTRODUCTION

The heat load of greenhouse is biggish, which is 2~4 times of civil residence. Concerned data show that the fossil fuel consumption of greenhouse is 0.3 kg/(d.m^2) in Shanghai, and 1.2 kg/(d.m^2) in Beijing. Geothermal energy used for heating instead of coal or oil could save fossil fuel. However, the early investment of geothermal energy development is considerable. Let's take the greenhouse in Dagang district for example: if geothermal water temperature exceed 80ºC was desired, the well depth must be more than 2000 m. In addition, the well head, heat exchangers, heating pipeline and pump station all need plenty of funds. Therefore, the limited geothermal resources must be utilized to the best. Improving the efficiency of geothermal utilization, adopting peak load regulating and decreasing the backwater temperature are all effective methods.

The geothermal field located in Dagang district, Tianjin city, which is low temperature geothermal resource. One geothermal well which is 2398 m deep was drilled in this field on April, 1977. At that time, geothermal water temperature and massflow were was 86ºC and 44kg/s respectively, and this well only used for fishery. An agricultural greenhouse was set up later in order to avoid energy wasting. The intending area of this greenhouse is 220,000 m^2, there are only 10,000 m^2 have been developed so far.

2. THE EFFICIENT UTILIZATION OF GEOTHERMAL RESOURCE

Drilling a geothermal well cost plentiful funds. A 2000-3000 m deep well would costs 2-4 million RMB, so it is very important to use the geothermal energy to the best. For instance, if the geothermal water temperature is 90/50 ºC (supply/return temperature), only 40ºC temperature difference is used. If the return temperature decreased to 30ºC, then the available temperature difference would be 60ºC, thus the efficiency of geothermal utilization would increase more than 50%. So decreasing the return temperature is a good way to improve the efficiency of geothermal utilization.

2.1 Improving the Efficiency of Geothermal Utilization

The key to improving the efficiency of geothermal utilization is decreasing the backwater temperature. In order to reduce the backwater temperature, geothermal water should be utilized stepwise. That is to say, geothermal water coming from the well entered into radiator first, then underground heat exchangers and the rearing pond in series (for fishery 15-18ºC water temperature is sufficient). Furthermore, partial backwater could also be mixed with fresh geothermal water to heat again, the proportion between them varied automatically by temperature regulator. Most of radiators in geothermal greenhouse are aerofoil cast iron one. Though the more radiators, the lower backwater temperature, there is a limit number of radiator. Over this number increasing radiators can only produce tiny temperature difference, and it also make the initial investment increase and much space occupied.

Underground heat exchangers are the important ways for heating system. Low temperature floor radiation space heating system that have been popularizing extensively in recent years is a type of underground heat exchangers. Temperature of hot water for floor heating may be range from 45ºC to 55ºC but cannot exceed 60ºC, which coincide with the temperature of geothermal backwater. By using underground heat exchanger the efficiency of geothermal utilization can be enhanced greatly. Another way of underground heat exchangers is laying pipelines under the plant roots directly to increase soil temperature. Some studies show: plant output would enhance 5% if soil temperature increased 1ºC. Floor heating is suitable for most production greenhouse with a little unoccupied space. Normally pipelines are laid 0.5 m deeps under the ground (experimental results indicate in this distance the soil temperature is stable).

2.2 Geothermal Heat Storage to Peak Load Regulating

Geothermal heating for greenhouse is different from civil residence. That the greenhouse walls are transparent is good for sunlight incidence in the daytime but is adverse during night because of the abundant heat loss through surroundings. Normally solar energy is enough to maintain the desired temperature in the daytime whereas at night geothermal energy couldn't supply the requisite temperature for plant, especially in severe winter, so usually boiler was used for peak load regulating. In order to saving limited energy, it is better to store this unused geothermal energy during daytime for peak load regulating energy during night. On the other hand, which also avoid to stop pump in the day thus prolong the lifetime of submersible pump. Next the emphasis on heat storage will be discussed.

The key to heat storage technique is excogitating a heat preserving, impervious and cheap heat storage material, which will be discussed in the following.

2.2.1 Selection of Heat Storage Device

Heat storage device is pivotal in heating system. It should be well heat preserving, impervious, longevity of service and cheap. Generally there are two shapes of water deposited device: pot and pond. Water deposited pot are usually laid on the ground and volume less than 100 m^3. According to the stuff, there are steeliness and nonmetal, such as FRP, which is perfect in heat preservation and anti-leakage but expensive; the structure of water deposited pond have two kinds(earthwork and reinforcing steel bar), which volume is bigger than the former but water temperature is relatively low. Peak load regulating need vast geothermal water, it is practical to use water deposited pond for peak load regulating, anticorrosive, rainproof and heat preserving are important parameters for the pond.

Presently there are two types of heat storage pond to be selected.

1) Underground earthwork pond;

Digging an earthwork to design elevation, the PVC salt film was laid around the pond to prevent the geothermal water from being polluted.

2) Underground concrete pond

The wall and bottom of pond are all concrete and PVC salt film is also used.

For underground or semi-underground heat storage pond, heat loss in surface is considerable, so pond surface must be covered with heat preserving films.

A semi-underground concrete heat storage pond with 50m^3 was finally designed in this paper. The sides of this pond are built with reinforcing concrete, the dimension is 3.3m×6.9m×2.5m, and bottom elevation was -1.3 m. See in Fig.1. In addition, the salt film was acted as waterproof considering the special demand, heat-resistant and anticorrosion experimentation also have been done, the results indicate: the salt film is a perfect waterproof material to the heat storage pond.

There are three kinds of heat loss for the pond surface, which is evaporation heat loss, convection heat loss and soil heat loss. Evaporation heat loss is primary which is about 70□80% of the total. PVC covered water surface to prevent heat loss because of its good properties and cheapness. In this experiment we considered two shapes of PVC, spherical and tabulate. spherical PVC have less weight and easy to produce static, it is difficult to distribute evenly, and that the distance among them is not enough obstruct water evaporation completely, tabulate PVC is better, it has a close structure without aperture, which could cut off water evaporation entirely, ambient aperture in the pond could be filled with sphere one. According this heat preserved effect is good. For two shapes PVC, Experimental results of heat preservation shown in Table 1.

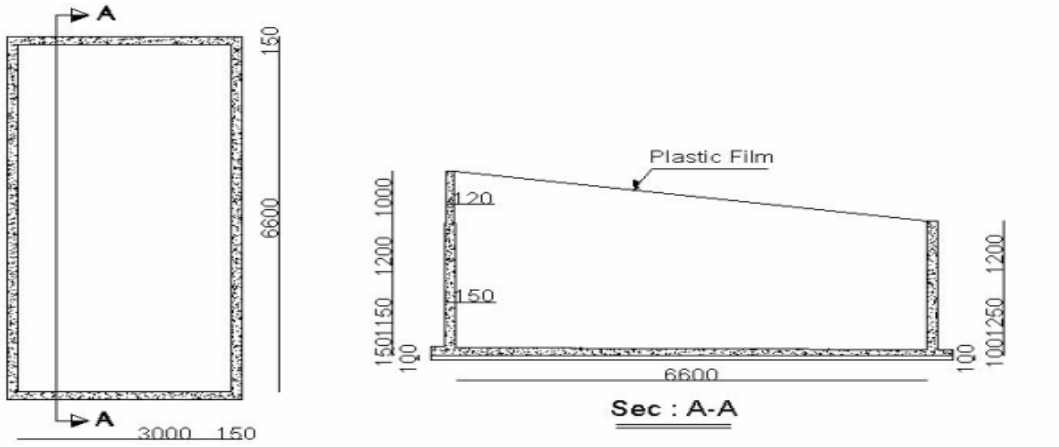

Figure 1: Ichnography and Section Plane of Water Deposited Pond

Table 1: Experimentation Results of different heat preserving films

Heat preservation films	Inflow time	Inflow T	Outflow time (next day)	Outflow T (ºC)	Average T drop (ºC/h)
No heat preservation	11:00	79.3	9:00	40.8	1.75
2cm thickness (s)	13:00	78.8	9:00	69.4	0.47
3cm thickness (t)	14:00	80	9:00	72.9	0.37
5cm thickness (t)	14:00	82	9:00	75.4	0.35

(s: spherical shape; t: tabulate shape).

2.2.2 Heat Preservation for Pond Surface

According to the experimental results, we can see 5cm thickness (t) is better used for heat preserving film. Heat loss also can be calculated follows:

$$Q = C.m.\Delta T$$
$$= 4.186 \times 50 \times 1000 \times 0.35 / 3600 = 20.3kW \quad (1)$$

Where Q, C, m, ΔT are heat loss of the pond, specific capacity of water, the mass of water in this pond and temperature drop, respectively.

t can be seen that the heat loss is low, so using heat pond to store geothermal water for peak load regulating during night is a feasible way to improving the efficiency of geothermal utilization and saving the fossil fuel.

3. CONCLUSION

Geothermal energy is a renewable resource, which exploitation and utilization can save a great deal of fossil fuel and avoid environmental pollution, both economical and environmental benefits are obvious. In recent years geothermal energy have been utilizing widespread for greenhouse heating. Improving the utilization efficiency of geothermal energy and peak load regulating are effective ways to the geothermal resource utilized perfectly. According to the experimentation of two shapes of PVC films for reinforced concrete pond, tabulate PVC was proved that it is a good heat preserving film because of low heat loss, which is satisfying and can supply some references to practical project.

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