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OPTIMIZATION ANALYSIS ON VARIOUS PEAKING INSTALLATION SCHEME FOR LOW TEMPERATURE GEOTHERMAL ENERGY SPACE HEATING

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ABSTRACT

This paper is aimed at the various peaking forms the selection of peaking, in China's present geothermal heating system. The existing problems have been studied and analysed thoroughly, based on large-scnle investigation and experiments as well as analysis and synthesis of conditions nt operation of the users. The author has put forward an optimal scheme for the peaking forms, equipment and the selection of heat sources, according to different regions, wnter quality, water temperature and users actual condition, so that designers and users mny avoid. random selection and unnecessary waste.

PREFACE .

At present, in the areas nround Beijing and Tianjin geothermal space heating has been used by a centain number of users. The earlier heating system of these geothermal users were the direct ones (the geothermal heating wnter directly enters the system and then is drained away). In order to save energy, lower the draining temperature of the geothermal heating water, raise the utilization efficiency, enlarge the heating areas and extent the service life of the heating system, a new geothermal heating system begins to use peaking facilities is designed. The geothermnl heating wnter of low temperature used for heating hus ita difference from that used for regular heating. Its features are as follows: tlie wnter temperature is usually rather low, with mnny mineral substances in it, the differentiation of the water quality is quite great, the geothermal heating water can't be used in circulation and the energy can't be regenerated. Therefore the optimum peaking facilities, the form of pealcing and the different situation. This is what this article tries to deal with in detail.

The change of corrosion of the low temperature geothermal heating and scale with the change of temperaure.

The temperature effect on the corrosion and scale is vital since the direct peaking system is to heat up the geothermal water directly. In some sense it decides the form of peaking system. Thus we first discuss the temperature effect on corrosion and scale so as to lay the basis for the questions to be discussed later.

1. The effect of temperature on corrosion

In geothermal water there are mainly seven chemical substances which strongly affect the corrosion, including O_2, H^+, Cl^-, H_2S, CO_2, NH_3 and SO^{2-}. In different geothermal zones the seven chemical substances is different, which determines the degree of corrosion to the equipment. The different element corrode different metals to different extent, Up to now most boilers and radiators made in China are manufactured by materials of carbon steel. The content of O_2 in the geothermal water has the strongest corrosion effect on carbon steel, mainly because O_2 and other elements act upon each other. O_2 with 30 ppb ($1ppb=1/10^9$) in geothermal water will cause the average of corrosion acceleration of' carbon steel to increase by 4 times. The several other elements have less effeot than O_2 . Most O_2 in the geothermal wnter are the wnter leaking from the air because of the leaktight system, after the geothermal water is drained from the well. Therefore the leaking of the air in tlre direct peaking system should be avoided as much ns possible. Usuallythe corrosion acceleration of the geothermal water to metal is in direct proportion to temperature.

2. The effect of temperature on scale

In the geothermal space heating system, scnle should be set much store by. The scnla in the system piping will raise the resistance of fluid, increase the consumption of energy and decrense the transmitting of heat, The scale on the side of heating of the heat exchanger will increase the resistance of transmitting heat, decrease the efficiency of transmitting heat and the incomplete parts of' the scale layer will make corrosion of inner scale, The scala formed by the geothermal wnter chiefly are of $CaCO_3$ scale, $CaSO_4$ scale, silicate scale and oxidizing iron scale. If the pressure of the system keeps the CO_2 not to be spilt, there won't be the problem of $CaCO_3$ deposit. $CaSO_4$ scale is subdivided into $CaSO_4$ nnd $CaSO_4+2H_2O$. $CaSO_4$ scale is mainly made of $CaSO+2H_2O$. Here the SiO_2 can't easily form scale in the low temperature geothermal fluid and won't be taken into consideration. The influence of temperature on dissolution is in figure 1.

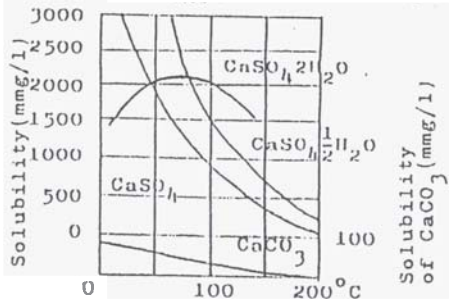

Fig. 1 Relation between the temperature nnd the solubility of calciferous salts

Figure 1. shows that the dissolution decreases as the temperature increases. This analysis of the effect of temperature on the corrosion of cnrbon steel and acnle has laid basis for the following analysis.

The analysis of the choice of peaking hent source.

Since the geothermal water is heated to make

peaking, the choioe of heat source must be dealt with. In faot there are many kinds of heat sources. The boilers used for peaking include boilers consuming coal, oil, natural pas and gas. Among them the boilers of coal combustion and of natural gas oombustion are suitable for the peaking of geothermal heating, beoaume the adjustment is very oonvenient. Their advantages will be shown in the later disoussion on the enoloaed geothermal heating system. The properties of the boiler comsuming oil are worse and the properties of the boiler comsuming ooal worst. To choose which kind of boiler for peaking is also confined to the regions so while considering the peaking, we must make ohoice in accordance with the actual situation of that area. If the working place can supply a steaming source, peaking with steam oan also be oonsidered, because this method has many advantages. Under special circumstances, electricity oan be applied to as a heat source. Although it is expensive, it oan be used to aohieve satisfactory effeot in special oases. Heat pump peaking has not been in ,use in China so far, for there is no capability in China to make such heat pump. If several kinds of the above heating sources are used together, there will be the best result. In the following discussion on the ohoioe of the form of peaking we'll put forward both advantage and disadvantage oaused by the choice of heat source aimed in the light ofconcrete speoifio conditions.

Several forme of the peaking of the low temperature geothermal heating and their analysis

1. The form of peaking geothermal heating system of direot boiler

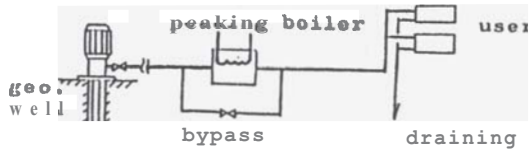

Fig.2 System diagram

When the outside temperature is higher than transient temperature (transient temperature has much to do with coal price and the author's oonolusion through optimal analysis, and caloulation is this temperature ia at 2 C to -2 C). the peaking boiler of the system dosen't start, the geothermal water passes through the bypassing pipe to the indoor radiator facilities and then is drained away. When the outside temperature is lower than the transient temperature, the geothermal water will directly enter into peaking boiler and raise its temperature. Afterwards it will be carried to heating users and will be drained via the radiator equipment.

This kind of peaking system is usually limited by the water quality beacuse of the opening formed system. In designing, the draining temperature must be taken into account and shouldn't be too high, usually at about 40°C.

This kind of peaking form generally needs high quality of geothermal water. If the draining water can be used as domestic water, the draining temperature can be raised in order to increase economical effioiency of utlization of geothermal water.

2. The geothermal heating system with direct steam peaking

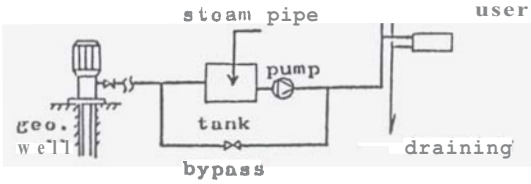

Fig. 3 System diagram

The form of this system is rather simple. For the users with steam source, it is easy to be realieed by only adding a water storage tank. (* the outside design temperature in Beijing and Tianjin is -9°C) (* the deoiding line to decide whether to start peaking equipment.) In order to prevent the air from leaking, the water-storage tank must be leaktight. When the outdoor temperature is higher than the transient temperature the geothermal energy supplies heating load and geothermal water passes through the bypass pipe so that the loss of the kinetic energy oan be avoided after the geothermal atoraee tank. Before the peaking steam is applied , the water-carrying pump shouldn't be started and the system resistance is overcome only by the geothermal well-pump. When the outdoor temperature is lower than the transient temperature, the bypass valve is turned off, the geothermal water carried to the water-storage tank and heated up by the steam directly to be sent to the users and then drained away.

This kind of system is suitably applied to the plaoe where there is the otenm source around the geothermal heating system, especially when the quality of water is not good. As mentioned Just now, when the temperature raises the corrosion of the geothermal water and scale both inorease. The corrosion and scale in this system of the geothermal heating with the direct steam peaking mainly occur in the water-storage tank, thus the corrosion and scale in the system io lessened.

The water storage is easier to be clehned or substituted and the investment is saved as well. This system also has the advantage of the stability of the water-power performance. Because of the function of the water-storage, the impure substances brought about when the geothermal well-pumps will precipate at the bottom of the water-storage tank, therefore there will be less scaling in the pipeline of the system. In the oase that the water quality is poor, this sort of peaking is worthy of popularizing for the users with steam source. This kind of peaking equipment has been used in the heating system of Beijing Costume Military Supplies Institute and the experiment has proved its operation works well.

3. The geothermal heating system with direct steam initrator peaking

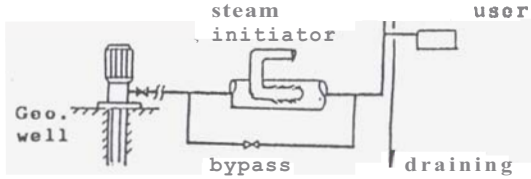

Fig.4 System diagram

This system is rather more simple compared with the geothermal heating system of direct steam peaking. All that is needed is to install a

steam initiator on the water-carrying pipeline of the user. So far steam initiators made in China have fallen into a pattern. (The user himself can process the steam initiator. For the detail please see the nationwide standard). This system needs high-pressure steam source. It espeoially can be used practically in the factories with steam power sources for the benefit of both less investment and greater economical efficiency. This system, however, has high demand on the water quality so it best is applied 'under the condition where the quality of the geothermal water is rather good. So far there has been no heating user in China who uses the kind of peaking.

4. The geothermal heating system with electrical heating peaking

In most areas of North China, electricity comes from thermal electrogenerating. The hydraulic one makes up only small proportion. As the second energy, the price of electricity is expensive. With regard to money-saving, electrical peaking is seldom used. However there are some exceptions. Taking the hothouse where the quantity of heat is supplied by the geothermal water as an example, this quantity of heat can satisfy the design load(See Fig. 5). Part of the shadow is designed for the non-guarantee days. The crops in the hothouse night be froeen to death in these nonpuarantee days and make severe economical loss. In this situation, electrical heating peaking may be applied to end the quantity of heat for peaking is shown only in the part of shadow and uses a small amount of electricity without greet loss in economy.

There is another situation in which electricity and other thermal sources can be used together to peak. It's used for the heating users when the demand for temperature is rather high and the temperature flactuation is not large. That is the system in which the heating seasons is not allowed to have non-guarantee days. Under the condition that the use of electricity is not great, this system leads to very good economic result. When the outside temperature is lower than the transient temperature,start the other peaking equipment, when it is lower than the design temperature, start the electrical peaking. This combining peaking method can not only get ideal effect but also increase by a big margin the utilization of the geothermal water. Fig.6 and Fig.7 illustrates that the proportion of electrical peaking is only a small part. For example. Beijing and Tianjin it only takes 2% of the total heating load annually.

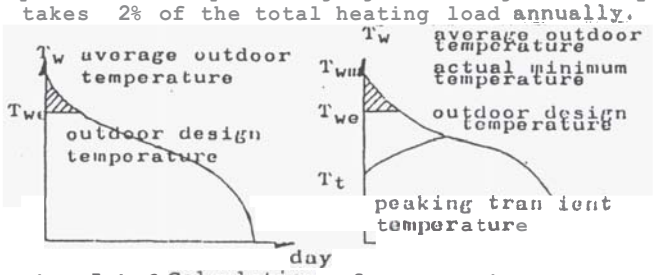

Fig. 5 & 6 Calculation of consumption according to outdoor temperaure

5. the heating system with enclosed boiler peaking

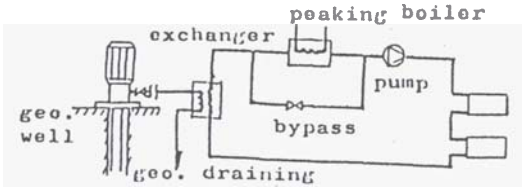

Fig.7 System diagram

This system is a regular and perfect geothermal peeking heating one. At the time being, China's geothermal heating generally uses direct heating system. As a result, most geothermal water has corrosion and scale. The use of the enclosed system can avoid the corrosion and scale of the heating system. Therefore the enclosed peaking system will be the main form adopted in the future design for the geothermal water with corrosion and scale. The advantages of this system are as follows: it is convenient for regulation,the heating is self-made system and there is no disturbance between the circulating water and the .geothermal water. Yet attention must often be paid to the purge of the plate heat exchanger used to exchange heat,. the suggestion is that the geothermal water pipeline may employ non-metal material of anti-corrosion so as to resist corrosion and save steel products. Usually the thermal insulating properties of non-metal material is better than that of metal material, On the other hand the disadvantage of this system is the increase of the investment of the heat exchanger and the decrease of the use quality of the geothermal water. This is because after the. circulating water is heated through the heat exchanger,the temperature at the esit is often lower 3 to 5°C than that of the geothermal water. This question should be taken into account in respect to the low temperature geothermal water with poor temperature quality. Through analysis of the optimum draining temperature of geothermal water,the author believes that if the geothermal water lower than 45°C adopts this form to peak, a poor economic result will appear.

The heating of the daily life area in Tianjin Guest Hotel uses the enclosed boiler peaking system. From 1986 to the winter of 1987. we made some conclusions about the system by comprehensive experiments. The peaking boiler of Tianjin Guest Hotel's geothermal heating system uses natural gas fuel and the geothermal water supply is adjustable so that the regulation the system is very convenient. During the warmer seasons (outside temperature at 3-5°C), the draining temperature can fall to about 30°C (the temperature of the well exit is 56°C)falls to 26% if we use temperature decrease, which benefits the utilization of the geothermal heating. As the geothermal water quantity is adjustable, the service life of the geothermal well will be extended. One thing needs to make clear is that bypass pipeline must be added to this kind of system, For example the geothermal heating system of Tianjin Guest Hotel without any bypass pipeline at first increase not only the resistance but also the inertia of regulation when the circulating water passes through the boiler without starting the peaking boiler. the radiation the boiler itself makes certain amount of heating loss. Later, as we suggest, the bypass pipe is added and the result is satisfactory.

6. The heating system of the intermittent pealcing of the enclosed boiler

The form of this system is similar to that of the enclosed boiler peaking heating system.The only difference is that when the outdoor temperature is lower than the transient temperature,the peaking adopts the intermittent peaking method. This is a new peaking heating form put forward according to the actual operation after we have tested the geothermal heating system in Tianjin Guest Hotel.(This article won't prove in detail the economic efficiency concerned). The intermittent peaking is only used for the heating of government administration and workshops whose work-time is in the daytime. The process to perform this system is as follows:At 6 o'clock (The workhour begins at 8 o'clock) in the morning begin to start the peaking boiler

(Under this condition the boiler is best to use natural gas or gas as fuel). At the same time turn the geothermal water flow to the smallest(The water pipe of the geothermal well must use adjustable motor to change the quantity of pumping water, but the geothermal well pump can't be turned off otherwise turning on or off the pump will damage the water layer of the geothermal well and affect the service life. Use the peaking boiler to heat the circulating water to 80°C--90°C with 1--3 hours of heating time. This time is deoided in accordance with the indoor temperature. Then turn off the peaking boiler, awaiting the circulating water temperature is lower 7°C or so than the geothermal water temperature. Afterwards adjust the flow of geothermal water supply.

At night, since no one works, the indoor temperature keeps at 10--15°C with no need to start peaking boiler. In this case, in 24 hours a day peaking boiler needs starting only 1--3 hours. Sinoe at 8 o'clock in the morning, the temperature of the circulating water is the highest and the indoor temperature is also higher, with the sunlight the indoor temperature during the daytime maintains at 18°C or so, which tallies the hygine standard of indoor temperature heating. It both saves the geothermal water,extends the servioe life of the geothermal well, and inoreases the utilization of the geothermal water as well. Acoording to our experiments. the lowest draining temperature of the geothermal water may reach 28°C at night. The experiment shows it is practicable for the government sectors and the factories whose workhours are in daytime. So far in China there is no user who adopts the method to peak.

7. Bnolosed heat exchanger peaking system

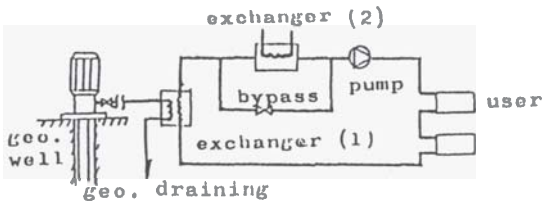

Fig.8 System diagram

This system is basically similar to the enolosed boiler peaking system. They are different in that this system is suitable for the newly-increased users of the original users after the geothermal well is dug. Fig.8 is the original heating boiler house of the users and the heat energy is supplied by the boiler house. The peaking system and the original boiler house form a circuit and the boiler house supplies either steam or hot water. The heat exchanger(2) can choose the common one which is low in price and is not anti-corrosion. There is no need for this peaking system to set up new boiler house,. because the general boiler house supplies the heat energy and the regulation is very convenient. When the temperature is higher than transient one, the system will pass through the bypass pipeline. The heat exchanger of the geothermal water may use anti-corrosion one. Such as titanium plate heat . exchanger with lees inveatment, this aystem have the same reeult as that of the newly-built boiler house under the condition that the original users posess a boiler house which can provide surplus energy. The kind of peaking method has been used in No.17 Teaching Building of Tianjin University.

POSTSCRIPT

All the geothermal heating users in China used non-peoking direct heating system: The utilization rate is very low, When 'the outdoor temperature is above 0°C, the temperature difference is only within several degree centigrade. Because of the peculiar advantage of the low temperature geothermal water, such as no pollution of powder dust, the people's oomfortablenesa and the thrife of high-position energy, the utilization of the low temperature geothermal heating developes rapidly. So far the study of the low temperature geothermal heating peaking system has been a newly opened domain, It is doubtless that the utilization of the geothermal energy will be raised when adding the peaking. With the development of the use of the peaking system, the research work has in turn been improved. The researchers engaged in the geothermal energy exploition and utilization have been studying the optimum references of the geothermal heating suitable to China's concrete situation as to provide scientific proof for the better opening up and using the geothermal energy. With the development of research, people have a better understanding of the use of the geothermal energy and of the effect of energy-saving when the peaking is added.

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