The approach on joint operation of modified waste oil well and lithium bromide absorption equipment

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Abstract: The oilfield left a large number of abandoned oil wells in the exploration process, selected suitable abandoned oil wells to be transformed into geothermal wells with development value, and combined the modified geothermal wells with lithium bromide absorption equipment to produce the required steam or cold water to meet the process and heating or the user's cold demand. This is a new method of geothermal energy utilization. The method is technically feasible, economically reasonable, and has a very broad application prospect.

1. Introduction

At present, most of the places with geothermal heat in China have been engaged in oil exploration and drilling, leaving a large number of oil wells that have no use value in oil exploitation. In 1995, in the oil and gas production work carried out by the petroleum system, there were a large number of exploration wells in various oil fields. The oil wells and water injection wells that were no longer used were listed as abandoned wells and written off in assets. The abandoned oil wells are rich in resources, and the energy saving potential in this aspect is huge. If it is used rationally, abandoned oil wells will become an important part of promoting China's energy conservation and emission reduction work[1].

Lithium bromide absorption equipment is a heat-driven, lithium bromide and water as the working system of refrigeration, heating technology. It is widely used in some areas where a large amount of driving waste heat or heat source is relatively inexpensive. In recent years, the research of lithium bromide absorption technology has mainly focused on two aspects: refrigeration and waste heat recovery. In the refrigeration technology, mainly based on renewable energy such as solar refrigeration and unit performance improvement; and in the waste heat recovery technology, mainly based on lithium bromide absorption heat pump application research and performance analysis[2-3].

The main purpose of this paper is to combine the geothermal well with the lithium bromide absorption equipment, use the geothermal well as the heat source, exchange hot water of 95 °C or lower, and then use the lithium bromide absorption unit to prepare the required steam or cold water for the purpose. Process and heating or the user's cold demand[4-5].

2. Working Principle of lithium bromide absorption equipment

Lithium bromide absorption unit is mainly divided into absorption chillers and absorption heat pump, lithium bromide absorption refrigerating machine mainly uses waste heat generator recycling 60 °C above, through the evaporator for making 5 ~ 30 °C cold water to meet the demand of the user's refrigeration; Lithium bromide absorption heat pump mainly uses evaporator recycling waste heat under 60 °C, through the absorber and condenser for making more than 45 °C hot water heating or process demand.

The main components of lithium bromide absorption refrigerator are evaporator, absorber,
condenser, generator, solution heat exchanger and solution pump. In the generator, the lower concentration of lithium bromide solution is heated so that the water in the solution evaporates and the solution is condensed into a concentrated solution. The concentrated solution is sent to the absorber, which enters the condenser and condenses into cryogen water. Cryogen water through the throttling mechanism after the pressure into the evaporator evaporation heat absorption to make the cold amount, and then evaporated steam is absorbed by the concentrated solution in the absorber. The specific cycle principle is shown in Figure 1.

Figure 1 Schematic diagram of lithium bromide absorption refrigerator

The working principle of the lithium bromide absorption heat pump is the same as that of the absorption type refrigerator. It works according to the inverse Carnot cycle. The only difference is the operating temperature range. The absorption heat pump is divided into the first type of absorption heat pump and the second type of absorption. The first type of absorption heat pump is also called heat-increasing heat pump. It uses a small amount of high-temperature heat source (such as steam, high-temperature hot water, etc.) as the driving heat source to generate a large amount of medium-temperature useful heat energy\cite{6-7}. That is, the high-temperature heat energy is used to drive the heat energy of the low-temperature heat source to the medium temperature, thereby improving the utilization efficiency of the heat energy. The performance coefficient of the first type of absorption heat pump is greater than 1, generally 1.5 to 2.5. The second type of absorption heat pump, also called a warming heat pump, uses a large amount of medium temperature heat source to generate a small amount of high temperature useful heat energy. That is, the medium-low temperature heat energy is driven, and the heat potential difference between the medium-temperature heat source and the low-temperature heat source is used to obtain heat with less heat than the medium-temperature heat source, and part of the medium-low heat energy is transferred to a higher temperature position, thereby improving the utilization level of the heat source\cite{8}. The performance coefficient of the second type of absorption heat pump is always less than 1, generally 0.4–0.5. The two types of heat pumps have different purposes and work in different ways. The outline of the absorption heat pump is shown in Figure 2.
3. Selection and modification methods of abandoned oil wells and engineering examples

3.1 Selection of abandoned oil wells
It is especially important to carefully select well locations when rebuilding abandoned oil wells. First, detailed analysis and demonstration must be carried out by looking up the hydro geological conditions (formation, lithology, water-holding, permeability, etc.) of the well. Conditional wells (holes) should also analyze the thickness distribution of the aquifer. It is important to determine the thermal reservoir conditions of the well have any modification value. Then, collect the well history and well structure of the abandoned well. In addition, try to select the abandoned well that has been installed into the casing and has a complete well structure. Because the abandoned well with the two-opening well method has only 139.7 mm oil layer casing, the diameter of the pipe is finely affected, and the transformation is difficult and the effect is poor. The three-well formation method should be selected as much as possible, and the abandoned casing with the depth and diameter of the surface casing to meet the requirements of the submersible pump should be modified[9].

3.2 Waste oil well reconstruction plan and engineering example
The transformation of waste oil wells into geothermal wells is a new and meaningful attempt in the development of geothermal wells. The transformation plan is as follows:

1. collect oil well logging data and select the water layer.
2. a cement plug is placed around 50m below the water layer to prevent residual oil and gas in the lower part.
3. perforating the effective aquifer layer of the aquifer, the perforation layer thickness varies according to the water-rich condition of the sand layer.
4. the perforating well section is washed and washed, and if necessary, chemical well washing can be carried out to thoroughly remove the mud and mud cake remaining in the water layer, wash it to clear water, and obtain hydro geological parameters. Step work to lay the foundation.
5. the upper casing is modified. If the depth of the surface casing is in accordance with the requirements of the lower pump depth, the technical casing or the oil casing in the surface casing should be cut off, and the gap between the two pipes at the cutting point can be blocked.

3.3 Project examples
In the North China region, there is an abandoned oil well at a distance of only 300m from 12 locations in Huabei Oilfield. The well was an oil exploration well. It was drilled in May 1977. The drilling depth was 3071.13 m and the ash was sealed to 2795.14 m. It was scrapped due to no oil and gas display. The well transformation is divided into two steps. The first step is to acidify the open hole section of the lower dolomite, the second step is to rebuild the wellhead, and a new pump chamber is reconstructed to facilitate the pump. First, sleeve milling is carried out with a casing with a diameter of 244.5 mm. When the depth is 200 m, the casing is placed in the well, and then the technical casing of the original diameter of 177.8 mm is cut by 200 m. The gap between the pipe to be cut and the new
pump chamber pipe is sealed to ensure the normal operation of the submersible pump. After the pump was down, the water test and evaluation were carried out.

3.3.1 Basic overview of abandoned oil wells after transformation

After the transformation, the depth of the well is 1800m, the diameter of the wellhead is 200mm, the temperature at the wellhead is the ambient temperature, and the temperature at the bottom of the well is about 115°C. It can be considered that the temperature in the depth direction of the well is linearly distributed, that is to say, the temperature rises by 3.5m for every 100m decrease. °C. The basic situation is shown in the geothermal well overview of Figure 3.

![Figure 3. Overview of geothermal wells](image)

3.3.2 Heat extraction

Heat extraction of geothermal wells is an important part. Firstly, the temperature below the 70°C of the rock layer insulation, to prevent the heat exchanged from being carried away by the low temperature rock formations. Secondly, a heat-insulating pipe is set under the center of the wellhead, the pipe diameter is DN150, and the heat-insulating pipe is about 50m away from the bottom of the well. The circulating water flows down the well wall, forming convective heat exchange with the well wall, absorbing geothermal energy and increasing the water temperature. After reaching the bottom of the well, it is driven by static pressure, and the hot water flows out along the central insulating pipe to the wellhead. The process is shown in Figure 4 of the heat extraction flow chart.
Figure 4 flow chart of heat extraction

Model Establishment: set the well diameter $D_m$, well depth is $h_m$, start heat transfer depth $h_2$, the wall temperature at the beginning of heat transfer is $t_{h_1}$ °C, the bottom hole temperature is $t_{h_2}$ °C, inlet temperature of circulating water is $t_s$ °C, circulating water outlet temperature is $t_b$ °C, Heat transfer area $A_{m_2}$, Heat transfer coefficient $KW/(m^2°C)$. 

$$Q = AK (t_{h_1} + t_{h_2} - t_s - t_b)/2$$

which:  
$A = 2\pi D \times h_2$

For one with well wall temperature, heat transfer total load $Q$ About the function $K = f(Q)$

$th_1$ —— The temperature of the well wall at the beginning of heat change

$th_2$ —— The temperature at the bottom of the hole at the beginning of the heat exchange

$ts$ —— Inlet temperature for circulating water

$tb$ —— Outlet temperature for circulating water

Through the iterative formula $X_{n+1} = X_n - f(X_n)/f'(X_n)$ To calculate what meets the requirements. $K$ Value.

Take the above well as an example: $D = 0.3m$ ; $h = 2900m$ ; $h_2 = 1000m$ ; $t_{h_1} = 70$ °C ; $t_{h_2} = 115$ °C ; $t_s = 60$ °C ; $tb = 95$ °C

According to the above formula, you can calculate $Q$ is 3.3MW, if the effluent temperature is lowered $tb$, Then take the heat. Heat exchange $Q$ will improve. After the transformation, the outlet water temperature of the well is 92 °C, and the water collection is 100 m$^3$/h. After the transformation, the well led to a heating area of 210,000 m$^3$ and led 28 flower houses. It has been operating normally for four years and has achieved good economic benefits. The total cost of the well reconstruction is 380,000 yuan. It takes 3.2 million yuan to drill a geothermal well of the same type.

4. Combined application analysis of geothermal well and lithium bromide absorption equipment

4.1 Combined application of geothermal well and lithium bromide low temperature hot water machine

The main principle of the lithium bromide low temperature water heater is achieved by utilizing the evaporation pressure reduction of water at low pressure and the water absorption of the lithium bromide solution. The water has an evaporation temperature of 4°C at a pressure of about 800 Pa (6
mm Hg). When the water evaporates, it absorbs external heat to achieve refrigeration. As an absorbent, lithium bromide solution mainly uses its own water absorption to ensure the internal pressure of the unit is maintained at about 800 Pa (6 mm Hg). The main components of the unit are evaporator, absorber, condenser and generator.

As shown in Figure 5, the 95 °C circulating water from the hot well enters the lithium bromide low temperature hot water unit. The unit raises the heat of the circulating water, reduces the temperature to 60 °C, and then introduces it into the hot well for heat exchange through a circulation pump. The low-temperature hot water machine generates 7°C cold water driven by circulating water to meet the user's cold demand. According to the above calculation method, the cyclic heat can be roughly estimated to be 3.3 MW, and the low temperature hot water machine cooling capacity is $Q \times \text{COP}=2.1 \text{MW}$.

4.2 Combined application of geothermal well and second type absorption heat pump

The second type of absorbent heat pump is usually in the lower temperature of the residual heat (or waste heat) as the driving force, through the lithium bromide absorption heat pump unique function of "absorbing heat", the production of a higher than the heat temperature of hot water equipment. Typical features of this equipment are: in the absence of other heat sources or power, the temperature of the hot water is higher than the temperature of the driving heat source.

As shown in Figure 6, the 95 °C circulating water from the hot well enters the second type of absorption heat pump, and the heat pump raises the heat of the circulating water, reduces the temperature to 70 ° C, and then introduces it into the heat well for heat exchange through a circulation pump.
pump. The second type of absorption heat pump generates 0.4MPa of steam driven by circulating water heat. According to the above calculation method, the cyclic heat quantity can be roughly estimated to be 2.2 MW, and the heat pump heat output is \( Q \times \text{COP} = 0.7 \text{MW} \). The secondary heat pump unit can produce about 0.4mp steam 1t/h.

The geothermal well after the reconstruction of the abandoned oil well has a depth of about 1500m. In order to extract the underground heat source water, it is necessary to set up a pump room and use a deep well submersible pump for geothermal wells. The motor is connected with the water pump to complete the extraction of groundwater. The deep well submersible pump will be underground. The heat source water is extracted to the ground for heat exchange. The work needs to be \( W_1 \), and the appropriate water intake is 80m³/h. According to the work done by the pump, \( W_1 = \rho \times v \times g \times h \times k \) (correction coefficient), the well is roughly calculated within one hour. The submersible pump's work \( W_1 \) is 12MW.

For the lithium bromide low temperature hot water unit, the temperature of the 95 °C circulating water from the hot well is reduced to 60 °C, and the low temperature hot water machine is driven by circulating water to produce 7 °C cold water to meet the user's cold demand, which can be roughly estimated according to the heat exchange formula. The circulating heat is 3.3MW, the low-temperature hot water machine cooling capacity is \( Q \times \text{COP} = 2.1 \text{MW} \), and the appropriate water intake is 80m³/h. It can be estimated that the cooling capacity generated in one hour is 16.8MW.

According to the above estimation, the method is feasible from the technical point of view. From the economic aspect, considering the cost of rebuilding and drilling a new well, the former will save several times or even dozens of times, and the benefit is no different from a new geothermal well. Therefore, the operation scheme for transforming the abandoned oil well into geothermal and combined absorption equipment is technically feasible, economically reasonable, and has a very broad application prospect.

5. Problems needing attention in the reconstruction of geothermal wells in scrapping oil wells
   (1) For oil well reconstruction, it is first necessary to implement whether the oil well has been scrapped, and whether it will affect the oil recovery in the oil area after the transformation.
   (2) Understand the local geothermal temperature or the well temperature of the reformed well and the water content of the formation.
   (3) Geothermal wells should be distributed reasonably and the amount of mining should be appropriate to ensure long-term mining to improve economic efficiency.
   (4) Long-term dynamic monitoring of the production wells, continuous revision of mining plans, and rational mining.
   (5) After a well has been reformed, it has achieved a certain water discharge capacity. In order to make the well fully and reasonably utilized, pumping experiments, water quality analysis, data collection and geothermal well evaluation should be carried out.

6. Conclusion
Since the abandoned oil wells in the Three North area can reach thousands of ports, if it is discarded, it will waste huge energy, but if you choose the appropriate waste oil to make it into a geothermal well, use the geothermal well as a heat source, in exchange for 95 °C or lower. The hot water, and then use the lithium bromide absorption unit to obtain the required steam or cold water to meet the process heating or the user's cold demand. It is a new method of geothermal energy utilization. Firstly, the lithium bromide absorption equipment has the advantages of energy saving and environmental protection. Thermal energy is the driving force, in particular, low-grade thermal energy (waste heat, exhaust heat, etc.) can be utilized, and the wide adjustment range is highly adaptable to changes in external conditions. Secondly, since the heat exchange of the heat source water from the underground requires the submersible pump to work, this part is relatively power-consuming, so the shallower the well depth of the geothermal well after the transformation, the higher the benefit. People in the oil field will actively participate in this work and work together to make thousands of oil wells in the oil
field work.

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