Study on exploitation and utilization of geothermal resources in Henan Province

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Abstract. Geothermal is a kind of mineral resources with valuable comprehensive. It has many functions and wide use. In this paper, the present situation and existing problems of geothermal development and utilization in Henan Province have been discussed. On this basis, countermeasures including geothermal management and technical aspects have been put forward for rational, efficient exploitation and utilization of geothermal resources in Henan Province.

1. The distribution of geothermal resources in Henan Province

Geothermal resources in Henan Province can be divided into two types: one is low geothermal anomalies. Thermal reservoirs buried shallow with high temperature. It mostly in the form of springs exposed to the surface. The other belongs to normal geothermal warming. Thermal reservoirs are buried deep and must be exploited by drilling.

From the geographical distribution, the development and utilization of geothermal resources are wider in Henan Province (table 1). Many cities and counties have developed and utilized it. The water temperature is 40 – 50 ℃, and some can reach 60 ℃ or higher. The distribution of hot paddy field: the hot paddy field with high temperature is mainly distributed in the foothill where the thickness of the sediments is less, and the hot paddy fields with lower temperature are mostly distributed in the plain areas where the thickness of the sediments is larger.

2. Current situations of exploitation and utilization of geothermal resources in Henan Province

The development and utilization of geothermal in Henan Province can be divided into two stages: First, in the 1980s, the main development and utilization were low geothermal anomalies, and more performed as hot springs, developing recuperation and tourism. Second, since the 1980s, the development and utilization are mainly about the normal geothermal hot water.

Table 1 Distribution of geothermal resources in Henan Province

| Area of geothermal resources | Area of thermal storage/km² | Types of geothermal resources | Depth of well /m | Temperature/℃ |
|-----------------------------|-----------------------------|-------------------------------|------------------|---------------|
| Plain area in North Henan   | 5680.06                     | subsiding basin               | 1000-1300        | 40-70         |
| upwarping region in Western Henan | 5980.51                 | Upwarping, subsiding          | 0-2500           | 40-90         |
Middle and South Henan subsiding basin 1000-2673 42-63
Plain area in Eastern Henan subsiding basin 1000-1600 40-60

According to incomplete statistics the exploitation of geothermal resources in Henan Province is $4419.28 \times 10^4$ m$^3$/a till September 2016. The pore-type geothermal water accounted for 84.76% with temperature above 40 °C, the geothermal water accounted for 22.17%. The exploration type of geothermal resources is direct supply and ejection. It’s for the bath, city water supply, breeding, mineral water production, heating, etc.; their proportions were 56.44%, 38.13%, 1.64%, 0.26%, 0.24% respectively, and other uses is 3.29% (Fig.1).

The development of geothermal resources in Henen is mainly concentrated in the Huanghuaihai Plain including Zhengzhou, Kaifeng, Xinxiang, Anyang, Puyang, Zhoukou, Xuchang, Luohe and Luoyang as the main cities, followed by Luohe-north Zhoukou, Xinxiang-Puyang. In addition, the rest are sporadic mining. It is almost in the blank stage in the development and utilization of dry and hot rock in Henan. Dry-hot rock is a renewable special clean geothermal resources as one of geothermal resources. Experiments in developed countries have shown that the most viable technique for exploiting dry-hot rocks is the EGS (Enhanced Geothermal System), which is not limited by the natural geothermal field because the whole process is carried out in a closed system, and the key technology of heat recovery is to form heat exchange system in impermeable dry and hot rock mass.

3. Technologies of geothermal resources development and utilization in Henan Province
Nowadays, according to the characteristics of geothermal resources in Henan Province, geothermal wells is main geothermal resources for the development of drilling technology.

There are four main types in geothermal drilling: 1) Geological exploration wells used to get depth and fault structure of the stratigraphic section in the exploration area. 2) After a series of surveys and analyzes, exploration and mining wells are assumed that the exploration area has the conditions for the formation of underground heat reservoirs, but there are some important data to be identified. Under these circumstances, the exploration wells are arranged. 3) Exploitation wells. When the geothermal field is found and has been controlled in its scope, drilling for the purpose of mining geothermal resources; 4) Recharge wells. With the development of the geothermal field, the water level of the production layer will gradually decline. It needs recharge wells to recharge the water to the hot reservoir, in order to maintain the energy and water column of heat reservoir, and make geothermal fields stably product for a long term.
However, comparing with the international, geothermal resource development technology is less backward in Henan. The enhanced geothermal system (EGS) studied by geothermal research institutions in the United States has become the most promising geothermal technology. EGS is different from the traditional method of exploiting the geothermal resources in the permeable rock stratum by manually creating underground heat reservoirs and collecting energy from dry and hot rock layers which don’t have economical value. Therefore, Chinese geothermal development should be deeply progress to carry out Chinese "Enhanced Geothermal System (EGS)“ development and utilization of pre-research and preparation.

4. Problems of geothermal exploitation and utilization in Henan Province

4.1. Management issues

(1) Geothermal authority is not clear. Government and many related departments do not really implement a unified management. Management is very confusing. Chaotic and random mining and disorder are very common. Local government disturb and harass construction.

(2) Lack of exploration funds. Insufficient funds in the pre-exploration of geothermal resources leading to geothermal geological information is not detail, incomplete and geothermal geological foundation work is poor.

(3) Comprehensive utilization level is low. Geothermal resources is rich in Henan, but the utilization is single and disperse. There is almost zero geothermal field comprehensive utilization and cascade utilization, resulting in waste of resources. There are 1/4 of the land in Henan has geothermal resources and nearly half are used for bathing, public heating is less than 1%. Its energy resources utilization structure is irrational resulting in thermal pollution and damage of groundwater environment.

(4) Heat stored value evaluation are not inaccuracy. The government has insufficient funds in the pre-exploration of geothermal resources, which lead to the data released currently are mostly based on private survey data, coupled with the estimates by experts. In fact, no one knows the true geothermal stored value, which affected the province's geothermal energy development and optimization and adjustment of energy structure.

4.2. Technical aspects

(1) The development of geothermal resources in Henan Province is mainly concentrated in the 1000 ~ 1200 m thermal reservoir in Cenozoic Era, because of loose layer, low technical content, low difficult in construction and low investment. The base rock area has high investment and risk, high technical level and equipment requirements, so most units do not want to develop bedrock and deep geothermal resources. This has led to in the bedrock area geothermal development in a low exploitation stage in Henan[7].

(2) It is single that the means of geothermal resources exploration technology. The pre-exploration accuracy of blank area is low. Geothermal geology and geothermal drilling technology develop are slow. Especially in complex formation, it has low drilling efficiency, high cost and high accident rate.

(3) It is uneven that the level of geothermal drilling technology. The team anti-risk ability is low. Construction equipment and personnel are scattered. So they can’t unite to share information, and lower prices with each other. The internal construction technology standards and processes are various. Many advanced formation crafts and technologies of wells can’t be timely promoted to use and communicated, resulting in geothermal resources exploration and development can’t break through.

5. Countermeasures of geothermal exploitation and utilization in Henan Province

Aiming at the present situation and existing problems of Henan geothermal resources development and utilization, the following countermeasures are put forward.

(1) To establish geothermal management, unify management of geothermal resources, and be responsible for the province's geothermal energy resources, scientific management and planning and
confirming geothermal properties, specifying geothermal exploration market. To develop "Henan geothermal resources exploration and development management approach" As soon as possible, "Henan shallow geothermal energy exploration and development management approach", and develop relevant preferential policies and measures to encourage new energy exploration and development. At the same time, specify geothermal resources exploration and development team, and implement the construction team access system to avoid the quality of wells formation, the quality problems and series problems of geological environment caused by it, like groundwater pollution and land subsidence.

(2) Set up specialized geothermal exploration team, improve the quality of the corresponding staff, integrate geothermal exploration equipment, personnel, and unify management and schedule in order to provide hardware support for the exploration and development of geothermal resources to achieve a major breakthrough.

(3) Improve the approval and supervision mechanism, increase the investigation and punishment. Government must take strong measures to prohibit strictly "random, arbitrary, arbitrary charges" phenomenon continues to spread in order to develop this new energy resources scientifically and rationally.

(4) It is relatively simple for geothermal development technology, and it is blank or low exploitation stage in the dry hot rock area geothermal development in Henan Province. Therefore, we should actively introduce foreign advanced technology EGS, the technology has become the most promising geothermal technology.

(5) Develop "Henan geothermal energy development and utilization planning." As for the region where geothermal development and utilization of a higher degree should be designated as key protected areas. Encourage exploration and development of 1600 ~ 3000m geothermal energy resources. It should be classified as general protected areas, and can be moderately developed for the region where geothermal development and utilization of the general level. Other cities should be designated as encouraging development zone combined with their own conditions, developing and utilizing of Neogene and Paleogene geothermal energy resources.

(6) Widen the industrial chain to create geothermal brand. Geothermal is also a tourist resource. In some areas with rich geothermal resources and a certain geological phenomenon, construct "geothermal geology parks" or "spa health care resort parks". Use geothermal brands to promote tourism, real estate, health care and other industries by leaps and bounds.

(7) Increase core technology researches of exploration and development of the geothermal energy resources to solve the technical problems of geothermal exploitation in the re-emergence and avoid the land subsidence caused by decline of geothermal water level. We should be scientifically plan and rationally develop. Especially in the exploration of ultra-deep geothermal resources and drilling technologies, we must achieve breakthroughs and independent innovation.

6. Conclusion
Geothermal resources is a renewable clean energy. It can be applied to people's lives, thereby effectively reduce the consumption of civilian resources and pollution, ease the pressure on lack of energy and supply, and make a great contribution for the national energy-saving emission reduction policy. The development and utilization of geothermal resources Henan Province are wider. Many cities and counties are developing and utilizing it, mainly concentrated in Zhengzhou, Kaifeng, Xinxiang and other major cities. The development technology of geothermal resources in Henan Province is mainly geothermal drilling wells, but in the process of geothermal development, there are many problems, most of which mainly in the aspects of management and technical. Put forward the corresponding suggestions and solutions to these two problems. In the 21st century with rapid economic development, it is believed that the development and utilization of geothermal resources in Henan Province will be more and more extensive and the efficiency will be higher and higher.

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