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Carbon dioxide sequestration in brackish water: Principles, techniques and environmental benefits

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Abstract:
Carbon dioxide storage is a technology to separate carbon dioxide gas from the atmosphere and inject it into the brackish water layer to achieve the purpose of carbon dioxide emission reduction. In this way, carbon dioxide is dissolved in salt water and then sequestered in deep underground water layers, preventing it from being released into the atmosphere and causing a greenhouse effect. This technology can effectively reduce carbon dioxide emissions, but also can use geological structures for storage, has great potential application prospects. It is important to note that further research and practice is needed to address possible environmental risks and costs.
Keywords: carbon dioxide, carbon sequestration, salt water sequestration, supercritical carbon dioxide

1. Overview of CO2 brine sequestration

In the current severe situation of global climate change, with the continuous increase of industrialization and human activities, a large number of greenhouse gas emissions have led to the rise of earth temperature and climate change. Therefore, finding effective greenhouse gas emission reduction and storage technology has become an urgent task.

Carbon dioxide brackish water seal is an underground storage technology designed to sequester carbon dioxide gas in underground brackish water layers to reduce greenhouse gas emissions in the atmosphere. It mainly involves capturing and monitoring carbon dioxide gas and injecting it into underground brackish water layers for long-term storage. This technology can be used to achieve long-term storage of greenhouse gases, thereby reducing their impact on the atmosphere and climate system. By storing a large amount of carbon dioxide, effectively reducing the concentration of carbon dioxide, reducing the accumulation of greenhouse gases in the atmosphere, to a certain extent, slowing down the speed of global climate change, controlling the rise in temperature and reducing the risk of global climate disasters, contributing to the realization of the goal of reducing global greenhouse gas emissions, protecting the earth's environment,

In short, the background and purpose of carbon dioxide salt water seal technology is to deal with global climate change, and its significance is to reduce greenhouse gas emissions and protect

2. Overview of brackish water reservoir storage

2.1. Principle and mechanism of saltwater reservoir storage

Salt water layer generally refers to the groundwater layer with high salinity, which can not be directly used by human beings and the indirect utilization rate is small. The storage of salt water of carbon dioxide is one of the technologies of geological storage and utilization of carbon dioxide.

As for the properties of CO2 storage in deep saline water, it is generally believed that CO2 needs to reach a supercritical state. Under standard conditions, carbon dioxide is a very stable gas, while under supercritical conditions, its physical properties such as density and viscosity are quite unstable. With the increasing of formation depth, the density of supercritical carbon dioxide rises sharply at first, and tends to be stable when it increases to a certain stage. The sudden increase of pressure will promote the corresponding increase of physical properties such as the fluidity of supercritical carbon dioxide [1]. However, with the rise of formation temperature, the density and viscosity of supercritical CO2 decreased, and the flow rate did not change significantly [2]. When the density is less than water, the carbon dioxide produces upward buoyancy. In general, the physical properties of supercritical carbon dioxide are closely related to the formation environment.

In order to reasonably and effectively carry out the supercritical carbon dioxide brackish water storage process, the depth, temperature and pressure of the brackish water layer must be considered. Most CO_2 salt water projects are stored at depths of 2000-2500m. [3-10] The temperature is greater than 31.1 °C and the pressure is greater than 7.38 MPa. [11]

The general CO_2 storage mechanism is to inject supercritical CO_2 gas into the underground designated level through a special device to form an effective trap with a good cover layer to promote its long-term separation from the surface, and finally achieve long-term, safe and effective storage effect.

Solution and storage mechanism: The principle of most carbon dioxide salt water storage is to use the underground salt water layer as the storage medium, the carbon dioxide gas is injected into the salt water layer, the solution is formed in the salt water, the formation of carbonate and acid bicarbonate ions. After CO_2 injection, it will move upward to the junction of reservoir and cap, and then be driven by molecular diffusion at the interface of formation water and free gas phase. When CO_2 is dissolved in the formation brine, the density of the formation water increases slightly, triggering the downward flow of the formation brine. This process improves the mixing of formation brine and CO_2, forming a rapid diffusion mechanism, resulting in high CO_2 dissolution. This process has two main benefits: reducing the upward movement of carbon dioxide and increasing the storage capacity of geological formations.

Mineralization storage mechanism: Carbonate and bicarbonate ions produced after the dissolution of carbon dioxide will combine with minerals and organic matter in the brackish water layer to form stable inorganic carbonate sediments. This mechanism depends on the nature of the rock and water layer in the enclosed space, which can be fast or slow, effectively anchoring CO_2 to the rock for long periods of time. [12]

2.2. Research status at home and abroad

In 1966, Norway implemented the world's first CO_2 sequestration project in the North Sea, the Sleipner CCS project, which has a long operating time and a large amount of CO_2 sequestration, and developed a theoretical model to measure the CO_2 sequestration at the site through seismic waves. So far, it is the most typical case of CO_2 salt water sequestration. [13] The In Salah project In Algeria is also a relatively successful case of reservoir storage at present. In 2004, British Petroleum jointly undertook the In Salah project with Algerian National Oil Company and Norwegian Oil Company, which set up advanced detection system technology on the basis of the previous project. Able to detect gas, analyze and measure pressure, etc. [14, 15] In 2000, Japan first carried out an experimental project of CO_2 injection on land in Asia, and Japanese scholars also analyzed formation fluids through sampling at different depths, indicating that the injected CO_2 had dissolved in the brackish water layer. [16, 17] Most of the full-chain large-scale CCUS demonstration projects in the world are implemented in developed countries, but the CO_2 brackish layer sequestration has also been developed in our country. In 2010, Shenhua Group implemented the CO_2 saltwater storage project in the Ordos Basin, which is the first CO_2 capture and storage project in the world to achieve multi-layer injection and layered monitoring in the deep salt water layer with low porosity and low permeability. From 2011 to 2014, the project completed about 300,000 tons of CO_2 injection, achieving the expected effect, providing a typical case for China's CO_2 salt water layer storage technology. [18]

From the current situation of the worldwide CO_2 storage project, CO_2 injection storage in brackish water layer is completely feasible and can become the most important way of CO_2 geological storage and utilization. However, there are still many areas that need to be improved. For example, the locations of water-forming layer storage are distributed all over the world. Different monitoring methods need to be carried out according to different geological conditions. There are no relatively complete laws and regulations on brackish water storage, which is difficult to supervise. Moreover, there is a lack of complete economic evaluation of CO_2 brackish water storage technology.

CO_2 geological storage and utilization technology is the core of CCUS technology. CO_2 salt water sequestration is the process with the greatest potential to reduce carbon emissions, but China still lacks in the test and implementation of this technology, has not formed a complete industrial process, can not be widely used commercially, but in several other technologies are still in the exploration stage and test stage. It is necessary to increase the investment in the storage technology of CO_2 salt water layer and strive for large-scale industrial demonstration as soon as possible.

China's CO_2 saltwater sequestration and utilization technology started late, compared to developed countries there is still a certain gap, the most important is the lack of large-scale, full-chain, cluster demonstration projects, large-scale whole-chain whole-process clustering is the future development direction of CO_2 saltwater sequestration and utilization technology, we need to increase research efforts in scientific deployment. Solve the key technical bottleneck of the engineering of CO_2 salt water storage and utilization technology, and develop the key technology that takes into account economy, safety and high efficiency.

3. Environmental benefit and risk assessment

The sequestration of CO_2 brine may cause some geological problems:

(1) Storage layer stability: Choosing the right brackish water layer to store CO_2 is critical. If the salt water layer is unstable or there are geological faults, cracks and other problems, it may cause carbon dioxide to leak or seep into the surface or groundwater resources.

(2) Increased pressure: Injecting large amounts of carbon dioxide gas may increase the pressure of underground reservoirs, which may lead to deformation or fracture formation of geological layers.

(3) Permeability problem: The permeability of underground reservoir refers to the barrier ability of the reservoir to carbon dioxide gas. If the saltwater layer is highly permeable, it can cause carbon dioxide to leak to the surface.

In order to assess the environmental benefits of CO_2 sequestration, the following factors need to be considered:

(1) Reduce greenhouse gas emissions: Carbon dioxide sequestration is considered an effective way to reduce greenhouse gas emissions and can help reduce the risk of global warming and climate change.

(2) Water resources protection: If the CO_2 salt water layer storage process can avoid the pollution of groundwater resources and water quality deterioration, then this technology will be very beneficial to the protection of water resources.

(3) Geological layer stability: The benefit of CO_2 salt water storage also depends on the stability of the reservoir. It mainly includes the degree of earthquake and deep fault activity [19]. If the reservoir is stable and the geology is suitable, the risk of carbon dioxide leakage can be reduced, reducing the potential damage to the environment. The regions with weak seismic and tectonic activity, low population density and land use are suitable areas for CO_2 geological sequestration in deep salt water layer. Some environments have undergone multiple tectonic movements and contain multiple fault systems, which are not conducive to CO_2 preservation. [20]

(4) Social acceptance: The implementation of CO_2 salt water layer storage technology needs to be supported and accepted by the society. If the technology is widely accepted and can be implemented with community interests and safety in mind, the environmental benefits will be even greater.

To sum up, the geological problems caused by the storage of CO_2 salt water layer need to be carefully considered, and corresponding safety measures should be taken to monitor and manage. The environmental benefits of this technology should be evaluated by considering greenhouse gas emission reduction, water resource conservation, geological stability and social acceptance.

4. Storage potential and direction to be conquered

At present, there are still many problems to be solved in the worldwide storage of carbon dioxide salt water.

(1) Low technological maturity: Although the sequestration of saltwater CO_2 is already underway, it is still a relatively new technology and still faces several technical and economic challenges. Long-term monitoring and emergency systems need to be established.

(2) Limited number of global sequestration projects: At present, the number of sequestration projects in the world is small, mainly concentrated in a few countries, such as the United States, Canada and Norway.

(3) Relevant regulations and policies are still being developed: Since sequestration technology involves a large amount of carbon emissions and geological storage, relevant regulatory and policy frameworks need to be established to ensure safety and environmental protection.

(4) The cost is still high: The current cost of carbon dioxide saltwater storage is still high, which mainly includes the cost of capturing and transporting carbon dioxide, as well as injection and monitoring.

5. Conclusion

At present, the technology of carbon dioxide salt water storage is widely used in the field of carbon dioxide emission reduction and climate change, and is considered as a potential technology to slow down global warming. However, there are some challenges and risks, and future developments will require further improvements and innovations in technology to reduce costs, increase efficiency and reduce environmental impact. These include improvements in CO_2 capture technology, injection technology and monitoring technology. Since sequestration projects usually cross national borders, strengthening international cooperation will be an important direction for future development. By sharing experience, resources and technologies, it is expected to accelerate the development and application of CO_2 saltwater storage technology. The establishment of a sound regulatory and policy framework will be critical to the development of CO_2 storage in brackish water. Governments and international organizations can support the implementation of sequestration projects through incentives, tax incentives, and regulatory provisions. Ensuring the safety of the environment and personnel is an important task of mothballed projects. Future development needs to strengthen environmental and safety supervision, and formulate corresponding standards and guidelines.

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