Exploration on the Utilization, Treatment, and Resource Utilization of Oil-Based Rock Cuttings in Shale Gas Extraction Process

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Abstract: The oil-based rock cuttings generated during shale gas extraction are valuable resources that can be used to reduce environmental impacts and achieve economic benefits through treatment and resource utilization. Oil based rock debris can be utilized and treated through grinding, thermal resource utilization, chemical resource utilization, and use as building materials or fillers. At the same time, environmental management and monitoring, as well as economic feasibility studies, are also important aspects of exploring the utilization of oil-based rock cuttings. In the implementation process, cooperation and innovation are also key to promoting resource utilization.

Keywords: Oil-Based Rock Cuttings; Utilization Processing; Resource Utilization

1. Composition of oil-based rock cuttings

Oil based rock cuttings are composed of circulating oil based mud and drilling rock cuttings, with an oil content ranging from 15% to 20%, a water content ranging from 10% to 15%, and a solid content ranging from 65% to 75%. The organic matter content in oil-based rock cuttings is relatively high, usually accounting for 20% to 80% of the total volume of rock cuttings. Asphaltene is the main component in oil-based rock cuttings, usually accounting for 10% to 50% of the total volume of rock cuttings. Oil based rock debris also contains minerals such as clay minerals, quartz, feldspar, etc. These minerals are non organic substances in rock debris, which may come from primitive sediments or later sedimentation.

It should be noted that the specific composition of oil-based rock cuttings is influenced by factors such as geological conditions, rock debris sources, and geological history, so the composition of different regions and rock debris samples may vary. [1]

2. Relevant standards for oil-based rock cuttings treatment

The relevant standards for oil-based rock debris treatment mainly include environmental protection standards, health and safety standards, quality management standards, and treatment method standards. At present, corresponding environmental recycling and utilization measures have been introduced in China to address the issue of oil-based rock debris disposal. The most mature extraction technology is the LRET (Liquid Oil based Mud Reuse for Environmental Technology) technology, which uses centrifugal separation to separate the separated solid phase from the extractant, and then uses indirect heating to heat the extractant. The extractant is evaporated and separated at 80 ℃, leaving the recovered oil phase that can be used for the mixing and reuse of oil-based drilling fluids. The solid phase is dried and the oil content drops below 1% [2].

3. Utilization technology of oil-based rock cuttings

3.1 Pyrolysis technology

The use of pyrolysis technology can extract oil and organic substances from oil-based rock cuttings. This includes

methods such as Thermal Desorption and Oil Recovery (TDOR) and Thermal Desorption and Solvent Extraction (TDSE). By high-temperature heating, the oil and organic substances in oil-based rock cuttings are separated for further processing and reuse.

3.2 Landfill

After appropriate physical and chemical treatment, oil-based rock cuttings can be used for landfill. During the landfill process, oil-based rock cuttings need to be solidified to reduce environmental pollution and ensure sufficient stability and safety.

3.3 Biological treatment technology

The biological treatment technology of oil-based rock debris is one of the development directions for harmless disposal. Biological treatment mainly utilizes oil loving microorganisms to degrade and assimilate petroleum hydrocarbons as carbon sources, ultimately transforming them harmless into inorganic substances such as carbon dioxide and water. The degradation mechanism can be divided into two aspects [3]: ① adding high-efficiency oil-eating bacteria, nutrients, and biosorbents to oil-based rock cuttings; ② Enhance biological activity by aeration and adding nutrients such as nitrogen and phosphorus.

The advantages of biological treatment technology are as follows: ① Utilizing biodegradation, it has less environmental harm. This technology strengthens the natural process of biological treatment, and its final products are carbon dioxide, water, etc., which will not cause secondary pollution and directional transfer of pollutants; ② The price is relatively low, and the cost of adding bacterial strains is not high, which can save 60% to 70% compared to other treatment methods; ③ The treatment effect is good, and after biochemical treatment, the residual amount of pollutants is significantly reduced [4]. The disadvantage of biological treatment is that it has a long treatment cycle and is more dependent on the growth process of microorganisms. At the same time, it is also limited by the natural conditions of biological growth. The mineral oil used as the carbon source for biological growth during the treatment process is not recycled, resulting in a certain amount of resource waste.

4. Resource based applications

Resource based applications can reduce the demand for raw materials, reduce environmental pollution, improve resource utilization efficiency, and promote sustainable development. It is necessary to select appropriate application methods based on specific circumstances and requirements, and ensure compliance with local regulations and environmental standards.

4.1 Oil recovery

By using pyrolysis technology or solvent extraction technology, the oil and organic substances in oil-based rock cuttings can be extracted and used as renewable fuels or raw materials for industries such as oil refining and chemical engineering. Solvent extraction is a technique that uses suitable solvents to dissolve the oil and organic substances in oil-based rock cuttings. Commonly used solvents include petroleum ether, benzene, xylene, etc. The extracted solution undergoes distillation, condensation, and other processes to separate and recover the oil quality. Centrifugal separation is a technique that uses centrifugal force to separate the oil and solid in oil-based rock cuttings. By adjusting the rotational speed and centrifugation time, the oil is separated from the rock debris and then collected through a collection device for oil recovery.

4.2 Building Materials

After appropriate treatment, oil-based rock cuttings can be used as ingredients for building materials, such as concrete, bricks, and road materials. This helps to reduce the demand for natural resources. Oil based rock chips can be used as aggregates for concrete and participate in the proportioning of concrete. After appropriate screening and processing, oil-based rock debris can be used as coarse or fine aggregates for the preparation of oil-based rock debris concrete. This

concrete has low thermal conductivity and certain sound absorption properties. Oil based rock debris can be used as one of the raw materials for bricks, treated with appropriate consolidation materials and processes. Oil based rock debris bricks can be prepared by mixing oil based rock debris with cement, gypsum, and other consolidation materials, pressing and curing them. This brick has low thermal conductivity and certain corrosion resistance. After mixing oil-based rock debris with other renewable materials such as waste pulp and rice husks, green building materials can be prepared. These building materials have lower carbon emissions and energy consumption, meeting the requirements of sustainable construction [6].

4.3 Soil remediation

The organic matter in oil-based rock cuttings can be used for soil remediation. Adding oil-based rock debris to contaminated soil can provide nutrients and improve soil structure, promoting the bioremediation process of the soil. After appropriate treatment and solidification, oil-based rock cuttings can be used as soil amendments. Adding oil-based rock debris to contaminated soil can improve soil water retention, permeability, and fertility, providing a favorable environment for plant growth. Use oil-based rock debris as a surface covering material to form a soil protective layer. This can reduce direct exposure to contaminated soil, reduce water evaporation and wind erosion, protect soil quality, and promote plant growth. The organic matter and microbial residues in oil-based rock debris can provide nutrients and habitats, promoting the growth and activity of mycorrhizal fungi in the soil. The interaction between mycorrhizal fungi and plant roots helps to enhance the plant's ability to absorb and degrade pollutants, promoting the soil remediation process.

4.4 Filler Materials

The processed oil-based rock debris can be used as filling materials, such as filling soil, filling buildings, and roads. This helps to reduce the demand for natural resources and effectively utilize land. After appropriate physical treatment and screening, oil-based rock cuttings can be used as filling materials. Fill the soil with oil-based rock debris, fill gaps and potholes in the soil, and repair uneven ground to achieve land leveling, stability, and utilization. Oil based rock debris can be used as filling materials in construction projects. For example, in foundation filling, landfill construction, and road engineering, oil-based rock debris can be used to fill earthworks, reducing the demand for natural resources and reducing construction costs. Oil based rock debris can be used as embankment fill for highway and railway projects [7]. After appropriate treatment and solidification, oil-based rock debris can provide a stable filling foundation, increase the bearing capacity and anti settlement ability of the embankment.

4.5 Energy recovery

The oil and organic matter in oil-based rock cuttings can be used as energy resources. By high-temperature treatment or pyrolysis technology, oil-based rock cuttings are converted into fuel or other forms of energy.

4.6. Reuse of drilling mud

The drilling mud in oil-based rock cuttings can be recycled and reused after treatment and solid-liquid separation, reducing waste generation [8].

4.7. Site Reclamation

After processing oil-based rock debris, it can be used for site reclamation, including the restoration and reconstruction of abandoned mining sites and oil contaminated areas.

5. Conclusion

China has actively explored the energy recovery of oil-based rock cuttings, conducting research and application on technologies such as pyrolysis, solvent extraction, and combustion. By recycling organic matter and oil from oil-based rock debris, reliance on traditional energy can be reduced, and energy utilization efficiency can be improved. Some progress has been made in the utilization of building materials from oil-based rock debris. Properly treated and solidified oil-based rock debris can be used as raw materials for building materials, such as in the production of concrete and road materials. This

helps to reduce the demand for raw materials such as natural stones, reduce resource consumption and environmental impact. Research and application have also been conducted in the field of soil remediation using oil-based rock debris. The organic matter and nutrients in oil-based rock debris are used as additives for soil remediation, improving soil structure and promoting bioremediation processes by adding them to contaminated soil [9]. Attention has also been paid to the waste treatment of oil-based rock cuttings. By using methods such as physical and chemical treatment, oil-based rock cuttings are converted into harmless or low-risk waste to reduce the risk of environmental pollution. Actively carry out research and development work on oil-based rock cuttings, continuously innovate in extraction, processing, and utilization technologies, and promote the feasibility and efficiency of resource utilization. It should be pointed out that China still faces some challenges in the utilization of oil-based rock cuttings, such as technological level, regulatory standards, etc., which need to be further improved and improved. At the same time, strengthening the regulation and compliance of oil-based rock debris utilization, ensuring that the processing process meets environmental requirements, is an important direction for China's sustainable development in this field.

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