

Study on the Role of Microwave Absorbent in Microwave Pyrolysis of Oily Sludge

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Abstract

At present, the output of oily sludge in major oilfields is increasing year by year in China. With the severe environmental protection situation, how to efficiently and cleanly treat oily sludge is a big problem in the industry. Oily sludge has high ash content, high adhesion, complex composition and other special properties, the treatment is difficult. Among many processing technologies, microwave pyrolysis technology has the advantages of strong material adaptability, fast processing speed and recycling of resources. In this paper, the application characteristics and effects of different types of microwave absorbers in the microwave pyrolysis technology of oily sludge were analyzed, and the future development of microwave absorbers was prospected.

Keywords

The oily sludge; Microwave pyrolysis; Absorbent; The research progress.

1. Introduction

Oily sludge refers to the sludge mixed with crude oil, various products, residuum and other heavy oils. It is one of the main solid wastes generated in the process of oil field development, production and transportation, and it needs to be reduced, harmless and recycled. Random disposal of oily sludge not only causes waste of resources, but also pollutes soil and atmosphere. More seriously, the migration and infiltration of petroleum hydrocarbons in soil will pollute groundwater and cause permanent damage to the ecosystem. Therefore, it is necessary to strictly adopt advanced technology to treat oily sludge, while microwave pyrolysis technology is still at the stage of development in China.

2. Research status of microwave pyrolysis oily sludge at home and abroad

Oily sludge microwave pyrolysis technology to realize the resource recycling, using the method of distillation and thermal decomposition, in the high temperature, oxygen or anaerobic condition, using thermal instability of organic matter, the sludge into gas, liquid and solid phase, the pyrolysis gas with small molecular hydrocarbons, H₂, CO and CO₂ is given priority to, such as pyrolysis oil is given priority to with macromolecular hydrocarbons and water, pyrolysis tar is given priority to with inorganic minerals and carbon residue.

Microwave pyrolysis of oily sludge has attracted extensive attention in recent years because of its advantages of high efficiency, clean, pollution-free and convenient for automatic control. Wang Chaoqian [1] in view of the existing sludge pyrolysis technology such as such as the limited time consuming energy, carbon performance problem, the author presents a new microwave induced synergy of pyrolysis technology, namely only with conventional primary pyrolysis first to obtain the pyrolysis of microwave strengthen absorption substrate, with microwave induced their site effect, high energy in order to preparation of high performance, low energy consumption carbon sludge. Sun Jingxin [2] studied the microwave extraction of oily sludge in Daqing Oilfield. By comparing the microwave extraction, Soxhlet extraction and ultrasonic extraction of oily sludge, he found that the

microwave extraction saves time and reagents, and is conducive to the extraction of substances with thermal instability.

In order to further improve the thermal efficiency of microwave sludge and promote the rapid heating of the system, the addition of microwave absorbent into oily sludge has attracted extensive attention of scholars in recent years. Microwave absorbers used in microwave pyrolysis of oily sludge at home and abroad can be divided into four categories: the first type is mainly activated carbon; The second type is dominated by metals or metal oxides; The third is mainly alkaline, and the last is magnetic nanoparticles.

2.1 Activated carbon as microwave absorbent

Dong Yu^[3] and Salema^[4] et al. found that adding biochar with good dielectric properties to the pyrolysis reaction could significantly improve the heating rate of microwave pyrolysis and promote the pyrolysis of hydrocarbon substances in oil sludge. Wan Liguo^[5], Tian Yu^[6], Wang Tonghua et al.^[7] investigated the influence of activated carbon, SiC, Fe₂O₃ and carbonized sludge as additives on the sludge during microwave pyrolysis, and the test results showed that the additives could effectively reduce the amount and capacity of sludge. Menendez et al.^[8] added graphite or coke as microwave absorbent to oily sludge, and the temperature of sludge could quickly reach 900°C within 2min. Pan Zhijuan et al.^[9] studied the effects of adding different proportions of activated carbon on the microwave pyrolysis process and product characteristics of oil sludge, and the results showed that the addition of absorbing medium could increase the heating rate of pyrolysis by more than 77%, reduce the solid residue rate of pyrolysis products by 24.7% at most, and increase the gas output by 46.9% at most. Chen et al.^[10] used granular activated carbon as a catalyst to catalyze microwave pyrolysis of oily sludge, obtaining high concentration of diesel and gasoline pyrolytic oil (accounting for about 70% of the pyrolytic oil), and at the same time inhibited the leaching of heavy metals. Li Xuanyuan^[11] analyzed the microwave pyrolysis products and found that the existence of "non-thermal effect" of microwave pyrolysis could improve the recovery rate of oil and gas. By adding 3% microwave absorbers, the recovery rate of oil products increased to 85.1% and the quality of oil products was improved. Dominguez et al.^[12,13] doped activated carbon with sludge for high-temperature pyrolysis under microwave heating and conventional heating conditions, respectively, and found that the output of H₂ and CO generated by microwave pyrolysis after using absorbent was higher than that of conventional pyrolysis, and less harmful substances were produced.

2.2 Metal or metal oxide - based microwave absorben

Shiea et Al.^[14] found that the addition of Fe, FeCl₃, Al and Al₂O₃ (metal absorbents) would significantly reduce the content of carbon in the residue, while the addition of Fe₂O₃ would improve the quality of recovered condensate.

2.3 Microwave absorbent containing alkalinity

Azadeh B. Namazi et al.^[15] added KOH to the sludge and found through experimental investigation that using KOH as an alkaline absorbent not only greatly reduced the time of microwave pyrolysis sludge, but also reduced the activation energy of chemical reactions in the pyrolysis process.

2.4 Magnetic nanoparticle

Although adding microwave absorbent into sludge improves the efficiency of microwave pyrolysis to a certain extent, there are still some problems such as high treatment cost and high energy consumption. Compared with traditional wave-absorbing materials, magnetic nanoparticles have many advantages, such as strong wave-absorbing ability, low cost and recyclability. Therefore, the synergistic effect of magnetic nanoparticles and microwave is also of great research value. Liu Yiping et al.^[16] found that in the experiment of microwave assisted magnetic Fenton catalyst in treating dye waste liquid, microwave formed hot spots on the solid surface of the catalyst through the strong wave absorption of magnetic nanometer MgFe₂O₄ reagent, which accelerated the catalytic degradation reaction and reduced the reaction energy consumption. Moreover, magnetic Fenton catalyst could be

recovered by magnetic field. Qin Chenggang, Zhang Baoying et al.^[17] combined the Fenton oxidation system with magnetic nanoparticles CuFe₂O₄ to treat rhodamine B wastewater under microwave-assisted conditions, and found that the removal rate of rhodamine B wastewater could be increased to nearly 100% under the synergetic effect of magnetic nanoparticles and microwave.

3. The application prospect of microwave absorber in microwave pyrolysis technology

At present, the main treatment method of oily sludge in the industry is pyrolysis, which has the disadvantages such as high investment cost and complex treatment process, as well as the advantages such as large amount of sludge treatment, high efficiency and good recovery effect. The addition of microwave absorbent in microwave pyrolysis can enhance advantages and avoid disadvantages, expand income and reduce investment cost.

The application of microwave absorbers in microwave pyrolysis technology has the following four characteristics:

- (1) To improve the recovery rate of oil products and gas and expand industrial economic benefits;
- (2) Accelerate the microwave pyrolysis rate and reduce the time cost of sludge treatment;
- (3) Increase the heating rate of pyrolytic materials and effectively increase the calorific value of fuel;
- (4) Reduce the production of harmful substances and reduce the pollution to the atmosphere and ground environment in the process of sludge treatment.

The application of microwave absorbers in microwave pyrolysis treatment has a huge advantage to promote the future development of the industry. Therefore, the application research process of microwave absorbers in microwave pyrolysis technology cannot be stopped.

4. Summary

At present, a great breakthrough has been made in the application of different types of microwave absorbers in the microwave pyrolysis technology of oily sludge, but the field application experience is insufficient and the technology is not mature, which requires constant innovation and practical application. In the future study on the microwave pyrolysis technology of oily sludge, we should compare and analyze the advantages and disadvantages of different absorbers, and select the microwave absorbent as the main research and development object in strict accordance with the national requirements, with low cost, high efficiency and no pollution as the standard.

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