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Overview of Oil Sludge Combustion/Pyrolysis Utilization

Jiyin Liu, Hongpeng Li, Xinghui Li, Jianwei Dai, Yahui Lei, Yuanchao Jiang, Fuliang Li

PipeChina West East Gas Pipeline Company, Xiamen, Fujian, China

Abstract: With the development of society, the demand for energy is increasing day by day. Today, fossil fuels such as oil and natural gas are still the main energy sources in the world. During the process of oil extraction, refining, transportation, and wastewater treatment, a large amount of oil sludge is generated, which contains a lot of harmful substances that are difficult to degrade automatically. Therefore, international scholars have conducted certain research on the combustion/pyrolysis utilization of oil sludge and have achieved certain research results.

Keywords: Oil Sludge Combustion; Pyrolysis Utilization; Oil and Gas.

1. Introduction

Oil sludge is a solid hazardous waste formed by impurities and oil sand deposition in crude oil, which is generated during the process of crude oil extraction, transportation, storage, and refining [1]. For example, landing sludge generated from drilling, operations, pipeline perforation, as well as sewage tanks, settling tanks, and oil tanks at various joint stations; The oil sludge generated during the crude oil extraction process mainly comes from the bottom sludge of the crude oil tank, flotation tank float, and oil separation tank bottom sludge.

The production of oil sludge is inevitable in the petroleum industry. The production of oil sludge is inevitable in the petroleum industry, due to its characteristics of toxicity, flammability, and corrosiveness. With the development of oil and gas resources, the problem of oil sludge accumulation is becoming increasingly serious, posing a great threat to the environment and also a waste of resources. The treatment of oil sludge has always been a hot topic.

2. Common Treatment Methods for Oil Sludge

Oil sludge is composed of oil and mineral particles, water, and other pollutants, usually in a dark viscous form, and presents a complex emulsion system [4]. China produces over 5 million tons of oil sludge annually. There are currently three widely applicable oil sludge heat treatment technologies internationally, namely drying technology, pyrolysis technology, and incineration technology. At present, there are many applications of oil sludge drying technology both domestically and internationally. Oil sludge drying refers to the process of heating and drying the oil sludge to form dried sludge.

The common methods for drying oil sludge nowadays include: superheated steam jet drying system, turbine drying sludge drying technology, low-temperature vacuum dehydration drying technology, etc. [1].

3. Oil Sludge Combustion/Pyrolysis Utilization

Oil sludge contains organic matter, which can be burned with other fuels such as coal to generate electricity, or obtain pyrolysis gas, pyrolysis oil, and gel like substances through pyrolysis. Domestic and foreign scholars have also conducted extensive research on oil sludge. Wang Bin from China University of Petroleum conducted a study on the oil content analysis, industrial analysis, elemental analysis, and heat generation of the sludge from the Jilin Petrochemical Refinery. Through thermogravimetric experiments, he studied the pyrolysis and combustion characteristics of the sludge and calculated the kinetic parameters. The TG and DTG curves of the oil sludge are shown in Figure 1[6].

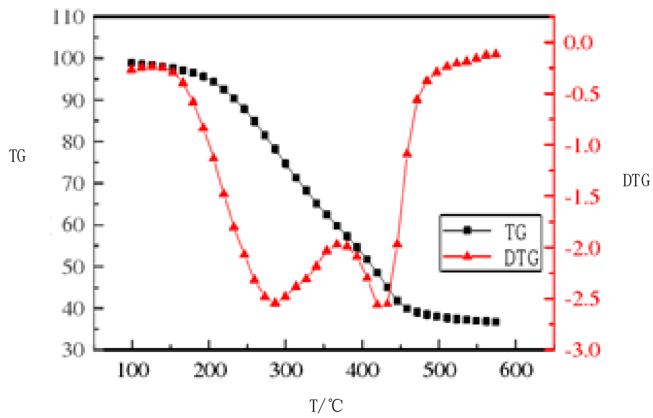

Figure 1. Thermal decomposition curve of Jihua oil sludge [6]

Rong et al. [8] conducted experimental research on the ignition and combustion characteristics during the co combustion process of rice stalks and oil sludge. The experimental methods used mainly include thermogravimetric analysis, X-ray fluorescence spectroscopy, etc. The conclusion drawn from the study is as follows: the reaction performance of the mixed sample has been improved, and there is a mutual influence and promotion effect between rice husks and oil sludge during the combustion process. Sun Wenyang studied the combustion characteristics of straw and oil sludge mixed fuel through experiments. The influence of blending ratio, temperature, and particle size on combustion of straw and oil sludge cold pressed mixed fuel was studied. The results show that when the proportion of oil sludge is 5%~15%, the combustion temperature is 750 °C~850 °C, and the particle size of the raw material is 8-12mm, the combustion performance is better and the SO2 emissions are less [7]. Figure 2 shows the relationship between combustion rate and SO2 emissions, as well as the particle size of the raw material. The maximum combustion rate and SO2 emissions curves of the blended fuel decrease with the decrease of the raw material particle size.

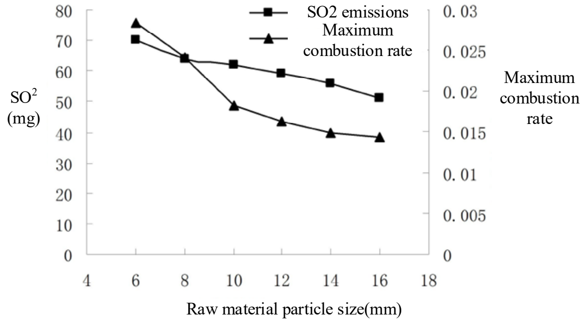

Figure 2. Relationship between particle size and performance indicators of different raw materials [7]

Lin et al. studied the co firing characteristics of sludge and oil shale using thermogravimetric analysis. Studied the combustion characteristics, combustion characteristic index, co combustion interaction, and DAEM activation energy calculation of mixed samples. The results indicate that when sludge is added, the ignition temperature of the sample transitions to a lower temperature, and the inhibitory effect in the co firing reaction is stronger under low temperature conditions. When the sludge mixing ratio is 10%, the calculated average activation energy value of the combustion reaction also reaches the minimum, and the model is in good agreement with the experimental data[9]. Wang Kai studied the mixed combustion characteristics of oil shale and shale oil mud, and used TG-FTIR technology to study the mixed combustion characteristics and gas release laws of the two. The synergistic effect of combustion was analyzed and dynamic calculations were carried out. Actual combustion experiments were conducted on the samples using a fluidized bed test bench to analyze the generation and release characteristics of combustion products under different combustion parameters. The results showed that as the blending amount of shale oil mud increased, The total NOx emissions from combustion reactions show a trend of first increasing, then decreasing, and then increasing again. As the proportion of shale oil sludge increases, the total amount of gas released increases [10]. Wang et al. used thermogravimetric mass spectrometry to study the combustion reaction process of oil sludge pyrolysis coke prepared at different temperatures. Through analysis of its ignition temperature, combustion rate, and comprehensive combustion characteristic index, it was found that pyrolysis coke from lower pyrolysis temperatures has better combustion characteristics [11].

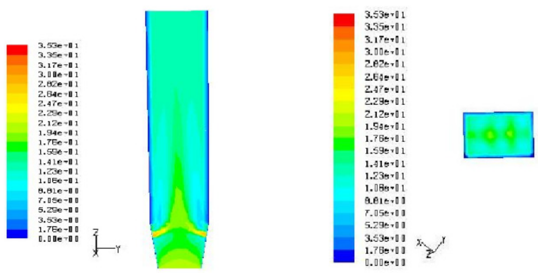
Figure 3. Fluent simulation results [12]

Wang Meiqiao used the Fluent software platform to numerically simulate and analyze the temperature field, velocity field, and pollutants generated during the combustion process of a mixed filter cake made of oil sludge and coal in a circulating fluidized bed furnace. As shown in Figure 3, some simulation results show that the volatile content of oil sludge in the filter cake is relatively high, which can promote combustion and suppress the emission of pollutants in the oil sludge [12]. Zheng Guoyao et al. adopted the fuel staged combustion technology of gas co combustion, which significantly improved the thermal efficiency of the boiler and reduced NOx emissions [13]. Chae et al. conducted research. Optimizing the position of the secondary air inlet and the proportion of secondary air can effectively reduce the emission of nitrogen oxides [14].

Liu Jianhua proposed the solidification incineration and comprehensive utilization technology of oil sludge by conducting research and analyzing the methods of oil sludge treatment. After the oil sludge is debonded and solidified, it is made into coal like fuel, mixed with coal, and used as fuel for coal-fired boilers[15]. Chang et al.'s research shows that as the pyrolysis time prolongs, the liquid phase products decompose again due to heating during the pyrolysis process, undergoing secondary reactions, resulting in a decrease in pyrolysis oil. The decomposition of pyrolysis oil will form small molecule hydrocarbons, corresponding to a decrease in liquid phase and an increase in gas-phase products [16-17].

4. Conclusion and Recommendations

Through the research and analysis of the Combustion/Pyrolysis of oil sludge, the conclusion is as follows: oil sludge heat has a certain amount of organic matter and has certain utilization value. The pyrolysis/combustion process produces toxic gases such as NO and SO2, and attention should be paid to the control of pollutants in the comprehensive utilization of oil sludge. Further research is needed on the division of oil sludge combustion/pyrolysis stages and their clean utilization.

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