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題目(和文)	オイルスラッジ焼却灰と水蒸気を添加した熱分解によるオイルスラッジからの燃料油回収
Title(English)	Oil Recovery from Oil Sludge Employing Pyrolysis Process with Oil Sludge Ash and Steam Addition
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## 博士論文要約

The major objective of this thesis is to investigate the effect of the oil sludge ash addition and steam injection on the yield and the quality of the oil product from the oil sludge pyrolysis. The first chapter of this thesis introduced the background of this research including: the flow and the environmental impact of oil sludge, the classification and the characteristic of oil sludge, and the review of the previous researches to give a more comprehensive understanding about the objective and meaningfulness of this research.

To explore the pyrolysis behavior of oil sludge, and to investigate the effectiveness and usage of the oil sludge ash, the pyrolysis experiments were conducted in the TGA and the two-stage fixed bed reactor in Chapter 2. The results indicated that:

1. For oil production, the one-stage pyrolysis pattern is more effective than the two-stage pattern, which means that feedstock should contact with additives directly during the pyrolysis process.
2. Oil sludge ash can be used as an additive in the oil sludge pyrolysis because: (a) Addition of oil sludge ash increased the oil yield significantly; (b) The quality of the oil products were improved by the presence of oilfield sludge ash.

In chapter 3, the comparison experiments of the oil sludge ash and the quartz sand in the stirred tank reactor were described to investigate the similarity and the difference between the effects of the oil sludge ash and the quartz sand during the oil sludge pyrolysis, further to understand if the oil sludge ash can provide the chemical effect. According to the results:

1. Addition of the oil sludge ash can increase the oil yield and reduce the optimal reaction temperature from 500 to 450°C, and
2. The oil sludge ash can inhibit the condensation reaction during the pyrolysis to a greater extent than the quartz sand
3. The presence of the oil sludge ash can reduce the carbon residue and increase the light oil/heavy oil ratio to a greater extent than the quartz sand

These results are due to not only the physical effect but also the chemical effect of the oil sludge ash during the oil sludge pyrolysis process. Therefore, in Chapter 4, the oil sludge pyrolysis experiments with the oil sludge ash and the main compositions of the oil sludge ash such as  $Al_2O_3$ ,  $Fe_2O_3$ ,  $CaO$  and the quartz sand were carried out to investigate the chemical effect and the possible catalytic reaction mechanism of the oil sludge ash. The results showed that:

1. Addition of the oil sludge ash,  $Al_2O_3$ ,  $Fe_2O_3$  and  $CaO$  to the oil sludge pyrolysis process reduces the carbon residue of the oil product and suppresses the migration of S, N and O from the oil sludge to the oil product, and increases the oil product saturation degree moderately.

2. These improvements of the oil product quality are attributable to the catalytic effect of the  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$  and  $\text{CaO}$  compositions in the oil sludge ash.

Through the discussion in Chapter 4, we found that  $\text{H}_2\text{O}$  might play an important role in the pyrolysis reaction between oil sludge and the oil sludge ash. In Chapter 5, we tried to use the steam injection technology during the oil sludge pyrolysis: (1) to investigate the effect of steam and the oil sludge ash on the product distribution and the oil product quality; (2) to explore the interaction relationship between steam and the oil sludge ash and the possible catalytic mechanism during the pyrolysis process. The results indicated that:

1. Both of steam injection and the oil sludge ash addition cause the increase of the oil yield.
2. Steam injection can inhibit the secondary cracking reaction, and then prevent the oil products from being further cracked to gas.
3. The oil sludge ash addition decreases the carbon residue and the Light oil/Heavy oil ratio by converting more heavy fractions or coke precursors to lighter fractions. The synergetic effect of steam injection and the oil sludge ash addition can further decrease the carbon residue of the oil product.
4. The presence of the oil sludge ash has a capability of decreasing the S, N and O mobilities of the oil product significantly. The synergetic effect of steam injection and the oil sludge ash addition can further improve this capability.
5. The obvious decrease of the carbon residue, and the increase of the isoparaffin index in the steam and oil sludge ash coexisting case might be attributed to the improved catalytic effect of the oil sludge ash by steam injection.