Study on flotation properties of emulsified diesel oil

Xie Weiwei*, Huang Kaiwu, Wang Donghui, Zhang Yuran, Liu Xiu

China University of Mining and Technology, Beijing 100083, People's Republic of China

Abstract

A new emulsified flotation agent with a compound of diesel, surfactant and water with a percentage of 27:3:70 was applied to the research on the flotation test with two coal samples of Guandi coal and Xingtai coal to solve the problem of low efficiency and high oil consumption of traditional flotation which used diesel itself to serve as the collector. The results showed that the flotation agent was good in performance and reliability, high in selection, and has improved the flotation performances. Based on the clean coal ash remaining unchanged, in comparison with the diesel, when EDO was applied as the collector of Guandi coal, the diesel oil could be saved about 73%, meanwhile, the clean coal production could be increased by around 3%. When EDO was applied as the collector of Xingtai coal, the diesel oil could be saved about 46%, meanwhile the clean coal production could be increased by 7% or thereabouts.

Keywords: flotation; flotation reagent; clean coal yield; environment friendly

1. Introduction

Coal dominant energy structure will last a long time since our country's oil and gas resources is poor, with the deepening of the country's energy consumption and pollution reduction policy, transferring the coal into clean energy, developing clean coal technology vigorously, increasing the rate of clean coal, and reducing the ash and inorganic sulfur in coal, which are favorable to protect the environment and reduce the waste of energy, improve energy efficiency. There are a lot of coal separation technologies, while floatation is still the most effective method of slime coal' separation at home and abroad at present[1,2]. The most important of floatation technology is how to selectively enhance the clean coal recovery[3].

* Corresponding author. Tel: +86-10-62331244-81, Fax: +86-10-62331344
E-mail: xwwcumtb@126.com.
Most coal preparation plants in our country have been used neutral hydrocarbon oil such as light diesel and kerosene as collector of the floatation, which have a large consumption, and problems such as the special control of the aviation kerosene, the high price of diesel oil, the low efficiency of floatation are serious as well[4]. Hydrocarbon oil such as light diesel oil and kerosene are always used as coal floatation collectors which may cause thick oil film, high viscosity, the ineffective secondary enrichment, and large amount of reagents. It is the main reason why slime coal pollution was serious[5]. Therefore, the performance of floatation agent is an important factor for floatation results. Looking for efficient and affordable agents is an important way to reduce floatation costs, improve floatation effect and increase economic efficiency.

It enhanced secondary enrichment effect and reduces slime pollution as viscosity of emulsified reagents and high ash slime’s adsorption on coal surface reduced. The results showed that emulsified collector can accelerate the diffusion of hydrocarbon oil in the coal slurry, and enhance its adsorption on coal surface to improve the hydrophobicity of coal’s surface. Which emulsified oil can reduce dosage of agent, increased flotation rate and improved the flotation treatment system, and greatly increased combustible material recovery and clean coal yield and other prominent particularities.

In view of the above situation, we applied to develop a highly efficient flotation promoting agents PGS, the main raw material of synthesizing this promoting agents is renewable natural oils, mainly are PGS emulsifier match with other kinds of surfactants, made the energy conservational and environmental protection flotation reagents EDO. The floatation agent is made of environmental protection renewable natural oils, high efficiency, low cost and good stability, and can reduce floatation clean coal pollution from high-ash slime.

2. Coal sample

2.1. Coal quality analysis

Two coal samples with different coalification range are used which are named as XT and GD respectively. Proximate analysis and ultimate analysis of the two coal samples are given in Table 1.

<table>
<thead>
<tr>
<th>Coals</th>
<th>Proximate analyses</th>
<th>Ultimate analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>XT</td>
<td>0.89</td>
<td>20.74</td>
</tr>
<tr>
<td>GD</td>
<td>1.46</td>
<td>29.12</td>
</tr>
</tbody>
</table>

The Table 1 shows obviously that XT coal sample is a low-middle ash with low volatile and middle-high fixed carbon coal; GD coal sample is middle ash with low volatile and middle-high fixed carbon coal. We also can see that XT is low sulfur coal and GD is middle-high sulfur coal.

2.2. Particle size analysis

According to national standard GB / T 19093-2003 "coal screening test methods", the small screening test results of XQ coal samples are shown in Fig.1.

For XT coal, with the particle size decreases, the yield has an increasing trend after reducing in general. In the range of 0.25 ~ 0.5mm, the concentration of coarse particles is relatively small. For GD coal, with the particle size decreases, the yield has an increasing trend after reducing in general. In the range of 0.25 ~ 0.5mm, the content of coarse particles is relatively more, and ash content is up to 59.04% which is
much higher than coal ash 29.32%, indicating that coarse particles contain a large number of mineral impurities, and ash content of other grains are higher than 13 %, which is not conducive to flotation.

![Cumulative Curve](image1)

As Fig.1 shows, cumulative curves of XQ and GD coal samples are both concave to the lower left corner, indicating that two coal samples contain a lot of fine particles and there is fine soil pollution. As the negative cumulative curve of XT coal sample displays, the yield of 0.075mm is about 40%, while within the effective flotation size 0.25mm ~ 0.075mm the content of particles is about 52%. Overall, both coal samples are easy-floating slimes for which it’s easy to get a higher yield of clean coal, but the problem of claying is serious for both coal samples because of their high yield and ash content.

2.3. Step by step releasing test

The theoretical curves of coal flotation yield and ash content, yield and frequency of separation are obtained by taking step by step releasing test, providing a reference standard for laboratory flotation tests. As Fig.2 shows, for the XT coal, with the rising of clean coal yield, clean coal ash rises slowly. While the clean coal yield is 4.19%, the average ash content is 4.96%; when the clean coal yield increases to 63.93%, the average ash content is slightly higher than 10%; when the clean coal yield continually increases to 81.14%, then the average ash content is 12.01%. Therefore, during the flotation tests, the clean coal yield should be controlled close to 80% in order to meet the requirements, and then the average ash content would be close to 10%.

As Fig.3 shows, for the GD coal, while the yield of product 6 is 59.78%, the average ash content has reached 40.18%; the average ash content of product 5 reduces to 14.36%, but it’s yield drops to 12.53% and cumulative yield just increases to 40.22%; it can be seen at the beginning clean the clean coal ash rises slowly with the clean coal yield, but rise sharply when the clean coal yield is up to about 14% with a modest growth in the yield. Therefore, GD coal sample is harder to float than XT coal sample.

3. Result and discussion

Table 2 Results of Basic floatation tests

<table>
<thead>
<tr>
<th>Coals</th>
<th>Clean coal yield%</th>
<th>Clean coal ash%</th>
<th>Combustible recovery %</th>
<th>Floatation Degree%</th>
</tr>
</thead>
<tbody>
<tr>
<td>XT</td>
<td>77.94</td>
<td>12.12</td>
<td>85.44</td>
<td>37.81</td>
</tr>
<tr>
<td>GD</td>
<td>42.76</td>
<td>8.39</td>
<td>55.05</td>
<td>42.60</td>
</tr>
</tbody>
</table>

The primary flotation tests for two coal samples are carried out at the dosage of collector(diesel oil) 1.0kg/t and the dosage of frother(2-octanol) 0.1kg/t.

3.1. Batch flotation tests(Collector Dosage)
The flotation tests for GD and XT coal samples are carried out at the same dosage of frother (2-octanol) 0.1kg/t and different dosages of collector (EDO). The results are shown in the Fig.4 below.

![Fig.4 Effect of collector dosage on XT clean coal recovery](image)

![Fig.5 Effect of collector dosage on GD clean coal recovery](image)

It can be seen from Fig.4 that clean coal yield and combustible recovery appear an increasing trend with the increasing amount of collector (EDO). When the dosage of EDO is 2.0kg/t, the clean coal yield and combustible recovery rate reaches the highest value of 84.88% and 92.78% respectively. The combustible recovery is also higher than diesel oil by nearly 40%. Considering all the factors reasonably, when the dosage of EDO is 2.0kg/t, the result of the flotation is relative to the best.

Fig.5 shows that for GD coal sample, at a certain frother dosage, the clean coal yield and combustible recovery are both at the highest when the dosage of EDO is 1.0kg/t. Furthermore, the clean coal yield and combustible recovery decreases with the collector increasing in general. Clean coal ash, which attains to the lowest at the dosage of EDO 1.0kg/t, ranges from 8% to 9% in the small-scale fluctuations. As a result, we can see that when the collector dosage is 1.0kg/t, the clean coal yield and combustible recovery reach the highest value. At the same time, clean coal ash is relatively low, which is only 8.23%. The result of the flotation is relatively to the best. Compared with diesel oil, EDO has a better effect, which can save 70% diesel oil. It can improve the clean coal yield in the flotation when drugs are increased appropriately. However, when the dosage of reagent is too large, EDO will have a restraint effect on the slime flotation.

For GD, the best dosage of EDO is 1.0kg/t. Therefore, using EDO as collector can save diesel oil 730g/t in the flotation and still has a 2.5% higher coal clean yield than diesel oil. For XT, the best dosage of EDO is 2.0kg/t. Then in the same way, we can get that using EDO as collector can save diesel oil 460g/t and the clean coal yield is higher than that of using diesel oil by 6.94%. Thus, EDO saves diesel oil significantly and has a promoting effect on clean coal yield. EDO has good practical value and economic benefits.

3.2. Batch flotation tests (Frother Dosage)

The frother dosage effect tests with two coal samples were carried out at the best EDO dosage determined above, the results shown in Fig. 6.

Fig.6 show that the clean coal recovery and combustible material recovery continue to decline after a sharp rise as the frother dosage increasing. The clean coal recovery reach maximum 86.51% at the frother dosage of 0.08kg/t, when the frother dosage is 0.1kg/t, the clean coal recovery is 84.88%. While the clean coal ash Sharp rise in the first and then slow down as the frother dosage increasing, at the frother dosage
of 0.1kg/t clean ash reach minimum. Combustible material recovery all surpass 90% at the frother dosage of 0.08kg/t and 0.1kg/t. But floatation Sophistication at the frother dosage of 0.1kg/t is much higher than 0.08kg/t, and have higher clean coal recovery and combustible material recovery and lower ash. Therefore, using EDO as collector, the optimal amount of frother for XT coal is 0.1kg/t. The clean coal recovery and combustible material recovery increased by about 7% than using diesel as collector at this point.

Fig.6 Effect of frother dosage on XT clean coal recovery

Fig.7 show that as the frother dosage increasing clean coal recovery of GD coal sample first increase to a maximum value and then decrease, the clean coal ash present reduce first and than increasing trend. The clean coal recovery, combustible material recovery and floatation Sophistication are all reached the maximum at the frother dosage of 0.1kg/t respectively, at the same time the clean coal ash is relatively low. While the collector dosage of 1.0 kg/t, the best frother dosage is 0.1kg/t for GD coal sample.

4. Theoretical analysis

The floatation of coal slime is a very complex process that involves three phases including gas, solid and liquid, and coal of different metamorphic grades have different floatability. Floatation agent functions by adjusting the interfacial properties of gas-solid, gas-liquid and liquid-solid interfaces, and intensifying the differences of surface nature between coal and minerals to separate them[6]. The non-ionic surfactant within the emulsified oil has relatively long polar groups, which makes it easy for the non-ionic surfactant to form hydrogen bonds with hydrogen atoms of oxygenic functional groups (—COOH —OH) on coal surface. Therefore, the partial coal surface with bad floatability becomes apt to adsorb oil agent, so its hydrophobicity is improved, making itself floatable.

The collector introduced in this research is a sort of emulsified oil which contains surfactant. On the one hand, the collector can achieve directional adsorption on oil-water interface and form hydration shell to prevent oil droplets from merging and decrease the surface tension of oil drops, therefore the constituent of diesel in the collector can be well dispersed among the ore pulp, and the chances of contact between coal surface and non-polar hydrocarbon-type oil can be increased. On the other hand, polar ends of the hybrid polar components are apt to interact with oxygenic functional groups on hydrophilic areas of coal surface, and the non-polar groups would settle towards water, leading to the hydrophobicity of some of the polar parts and, therefore, the variation in partial hydrophobicity. It would then promote the adsorption of diesel towards the hydrophobic part, thus further enhancing the hydrophobicity of coal. Overall, the hybrid polar components and non-polar components could cause an elevation in coal surface’s hydrophobicity, resulting in a great increase in floatation efficiency[7]. By using EDO, the
surface tension between oil phase and water phase would drop by tens of times, making it easier for micro particles of oil to disperse among water and form oil-in-water type emulsion. Therefore, the chances of contact between the collector and coal surface would be increased.

After emulsification, dispersion of EDO in water would be improved, and the size of oil drops would be minified, which, on the one hand, reduces the amount of collector adsorbed on the surface of coal particles as well as the total quantity of collector required in the floatation; and on the other hand, increases the probability of collision between coal particles and collector, and shortens the attachment period, thus improving the efficiency and general performance of floatation.

5. Conclusion

(1) Compared to diesel oil, EDO is a good emulsion flotation reagent as collector, which can save diesel oil about 55% under the premise of ensuring the clean coal yield. With the usage of the emulsified oil, the combustible recovery of floating slime is significantly higher than diesel.

(2) Using EDO as the collector is more effective to raw coal’s separation than diesel, which has high floatation efficiency, good selectivity, stability, and low cost. In the case of coal ash unchanged, with the usage of EDO, the clean coal yield can increase 2~7%, and diesel oil also can be saved 40% ~ 70%, which has great economic value of the popularization.

(3) In the test, when the feed concentration is 100g/L with EDO as collector and 2-octanol as frother, it turns out that, for XT coal sample, the best reagent system is EDO 2.0kg/t and 2-Octanol 0.1kg/t and the best reagent system is EDO 1.0kg/t and frother 0.12kg/t for GD coal.

(4) The resulting foam viscosity is low when using EDO as a collector, which is beneficial to the improvement of the clean coal filtering capability with less moisture product. Therefore, the study of collector emulsification technology has significant economic benefits.

Acknowledgments

This work was financially supported by “The Fundamental Research Funds for the Central Universities” (2009QH05) and “Program of undergraduate innovative experiment” (101208Z).

References


