DOE/PC/92546--TN

Technical Progress Report For The Project

NEW CONCEPT FOR COAL WETTABILITY EVALUATION AND MODULATION

DOE Project Grant: DE-FG22-92PC92546

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Report Period: January 1, 1995 - March 31, 1995

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STATEMENT OF OBJECTIVE

This project is concerned with the new concept for coal surface wettability and floatability evaluation and modulation.

The objective of the work is study the fundamental surface chemistry features about the evaluation of the surface wettability and floatability of coal and pyrite, and establish a new separation strategy which could contribute to advanced coal-cleaning for premium fuel application.

SCIENCE AND TECHNICAL PROGRESS

During this quarter, the mini-flotation cell tests are conducted to study floatability of coal and pyrite. The three coals, coal pyrite and Colorado mineral pyrite samples are used in these tests. The kinetic floatability of the five samples have been tested without collector, with 3% and 6% NaCl solution. The test results shown that there are good agreement between the experimental observation and the theoretical hypothesis about the new concept of the surface wettability and floatability of the coal and pyrite.

The experimental results indicate that the coal floatability increase rapidly, but the floatability of coal pyrite and mineral pyrite are not change significantly with the addition of NaCl in flotation. It can be seen that the coal floatability increase as NaCl concentration increase.

The Kinetic Floatability Test Without Collector(Natural Floatability)

The mini-cell flotation test results for Upper Freeport coal, Pittsburgh No.8 coal, Illinois No.6 coal, coal pyrite, and Colorado mineral pyrite without collector are presented in table 1 and the natural floatability of five samples are shown in Figure 1 to 5.

From the test results, the rank of natural floatability for five samples are:

Upper Freeport coal > Pittsburgh No.8 coal > Illinois No.6 coal > coal pyrite > Colorado mineral pyrite.

It confirmed that the coals have better natural floatability than the coal pyrite and mineral pyrite in flotation process.

The Kinetic Floatability Test With 3% NaCl Solution

The mini-cell flotation test results of the five samples with 3% NaCl solution are presented in table 2. It shows that the correlation between the flotation yield and the flotation time.

The test results of five samples with 3% NaCl solution are plotted in Figure 6 to 10. It can be seen that the flotation yield of Upper Freeport increase much more than the floatability of Pittsburgh No.8 coal and Illinois No.6 coal. However, the floatability of coal pyrite and mineral pyrite are not changed significantly. In other words, it shows that the NaCl solution can increase the floatability or decrease the wettability of coal. It means that the behavior of coal surface is more hydrophobic than pyrite surface. These tests indicate that the separation of coal and pyrite is more effective in the flotation of NaCl solution.

The Kinetic Floatability Test With 6% NaCl Solution

The mini-cell flotation test results of the five samples with 6% NaCl solution are shown in table 3 and the flotation yield vs time of five samples are illustrated in Figure 11 to 15. These results indicate that the rank of the kinetic floatability for five samples are below:

Upper Freeport coal > Pittsburgh No.8 coal > Illinois No.6 coal >> coal pyrite > Colorado mineral pyrite.

The test results shown that the coal floatability increase as the NaCl solution concentrate increase.

The Relative Flotation Speed and Floatability Evaluation

Ralph W. Lai discover a proportionality law of process, and used it to analyzed and interprete a multitude of kinetic phenomena, the mathematical form is given by equation (1)

$$\frac{dR}{dt} = K \frac{(R_i - R)}{t} \quad (1)$$

Where: R_i is the ultimate yield,

R is the yield at time,

t is the flotation time(minutes),

K is the flotation rete constant.

When $R_i = 1$, the equation can be transforted into the form as:

$$K = \frac{\ln[\frac{1}{1-R}]}{\ln[t]} \quad (2)$$

From equation (2), the flotation rate constant can be calculated using data of the table 1, 2, and 3. The flotation rate constant of kinetic floatability of five samples in the system of the distilled water, 3% NaCl solution, and 6% NaCl solution are presented in table 4. From table 4, it can be seen that the flotation rate constant of the coal samples increase rapidly with NaCl solution concentration increase, but the flotation rate constants of coal pyrite and mineral pyrite are not change.

The Hu's evaluation of relative floatability results for five samples between 3% NaCl

solution vs distilled water (or $K_{3\%NaCl} / K_{H_2O}$) and 6% NaCl solution vs distilled water (or $K_{6\%NaCl} / K_{H_2O}$) are listed in table 5. The results indicate that the NaCl solution can modify the coal surface, and as the concentration of NaCl solution increases the coal floatability increases, but the floatability of coal pyrite and mineral pyrite are not changed significantly.

The experimental results for NaCl solution show that the surface tension of inorganic electrolyte solution (NaCl solution) increases with increasing concentration of the electrolyte.

The test results confirm an interesting fact that there is good agreement between kinetic floatability (mini-cell flotation test) and the kinetic wettability (capillary rise test) in the system of the water, 3% and 6% NaCl solution.

FUTURE WORK

In the next quarter, the kinetic floatability of five samples by mini-cell flotation with collector, frother and both will be continued.

Table 1 Kinetic Floatability of Five Samples Without Collector

Time (minutes)	Yield (%)				
	Upper Freeport	Pittsburgh No.8	Illinois No.6	Coal Pyrite	Mineral Pyrite
0.5	1.780	1.203	1.240	0.146	0.174
1.0	3.766	2.672	2.203	0.252	0.403
2.0	4.723	3.012	2.409	0.532	0.660
4.0	5.612	3.406	2.629	0.629	0.909
8.0	7.195	3.603	2.972	0.775	1.118
14.0	8.404	3.949	3.335	1.061	1.235
20.0	10.244	4.429	3.921	1.375	1.344

Table 2 Kinetic Floatability of Five Samples With 3% NaCl Solution

Time (minutes)	Yield (%)				
	Upper Freeport	Pittsburgh No.8	Illinois No.6	Coal Pyrite	Mineral Pyrite
0.5	20.790	1.517	1.154	0.240	0.183
1.0	31.790	3.506	2.120	0.506	0.469
2.0	41.420	4.686	3.783	0.726	0.689
4.0	52.683	6.746	7.043	0.843	0.969
8.0	61.794	9.366	11.214	1.043	1.192
14.0	69.108	12.249	12.145	1.357	1.295
20.0	72.527	15.152	13.094	1.540	1.381

Table 3 Kinetic Floatability of Five Samples With 6% NaCl Solution

Time (minutes)	Yield (%)				
	Upper Freeport	Pittsburgh No.8	Illinois NO.6	Coal Pyrite	Mineral Pyrite
0.5	43.449	3.683	3.649	0.271	0.263
1.0	59.361	8.894	6.798	0.528	0.497
2.0	73.309	13.063	10.641	0.697	0.637
4.0	85.646	21.729	15.452	1.191	1.043
8.0	91.249	31.975	23.312	1.680	1.400
14.0	92.395	38.841	31.549	2.506	1.834
20.0	93.286	42.687	35.478	2.926	2.100

Table 4 Flotation Rate Constant of Kinetic Floatability for Five Samples

Samples	K_{H_2O}	$K_{3\% NaCl}$	$K_{6\% NaCl}$
Upper Freeport coal	0.02200	0.29092	0.61753
Pittsburgh No.8 coal	0.00708	0.03803	0.14519
Illinois No.6 coal	0.00622	0.03769	0.10941
coal pyrite	0.00309	0.00364	0.00725
Colorado mineral pyrite	0.00322	0.00329	0.00508

Table 5 The Hu's Evaluation of Floatability Between Without Collector vs 3%, 6% NaCl Solution

Samples	$K_{3\% NaCl}/K_{H_2O}$	$K_{6\% NaCl}/K_{H_2O}$
Upper Freeport coal	13.2236	28.0695
Pittsburgh No.8 coal	5.3715	20.5071
Illinois No.6 coal	6.0595	17.5900
coal pyrite	1.1780	2.3463
Colorado mineral pyrite	1.0217	1.5776

Figure 1 The Mini-Cell Flotation Test Results of Upper Freeport Coal Without Collector

Figure 2 The Mini-Cell Flotation Test Results of Pittsburgh No.8 Coal Without Collector

Figure 3 The Mini-Cell Flotation Test Results of Illinois No.6 Coal Without Collector

Figure 4 The Mini-Cell Flotation Test Results of Coal Pyrite without Collector

Figure 5 The Mini-Cell Flotation Test Results of Colorado Mineral Pyrite Without Collector

Figure 8 The Mini-Cell Flotation Test Results of Upper Freeport Coal with 3% NaCl Solution

Figure 7 The Mini-Cell Flotation Test Results of Pittsburgh No.8 Coal With 3% NaCl Solution

Figure 8 The Mini-Cell Flotation Test Results of Illinois No.6 Coal With 3% NaCl Solution

Figure 9 The Mini-Cell Flotation Test Results of Coal Pyrite With 3% NaCl Solution

Figure 10 The Mini-Cell Flotation Test Results of Colorado mineral Pyrite With 3% NaCl Solution

Figure 11 The Mini-Cell Flotation Test Results of Upper Freeport Coal with 6% NaCl Solution

Figure 12 The Mini-Cell Flotation Test Results of Pittsburgh No.8 Coal with 6% NaCl Solution

Figure 13 The Mini-Cell Flotation Test Results of Illinois No.6 Coal With 6% NaCl Solution

Figure 14 The Mini-Cell Flotation Test Results of Coal Pyrite
With 6% NaCl Solution

Figure 15 The Mini-Cell Flotation Test Results of Colorado Mineral Pyrite With 6% NaCl Solution