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Desulfurization of Various Midwestern Coals by Flotation

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UNITED STATES DEPARTMENT OF THE INTERIOR

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Desulfurization of Various Midwestern Coals by Flotation

By Kenneth J. Miller



UNITED STATES DEPARTMENT OF THE INTERIOR

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DESULFURIZATION OF VARIOUS MIDWESTERN COALS BY FLOTATION¹

by

Kenneth J. Miller²

ABSTRACT

Laboratory batch flotation tests were conducted to determine the viability of the Bureau of Mines coal-pyrite flotation process in desulfurizing various coals from the midwestern coalfields. Nine coals obtained from western Kentucky and Illinois were used in the study. In addition to the Bureau's coal-pyrite flotation process, some of the coals were subjected to two-stage rougher-cleaner coal flotation for comparison.

The results of this work showed that up to a 70-percent pyritic sulfur reduction could be obtained by flotation and that the Bureau's coal-pyrite flotation was superior to rougher-cleaner coal flotation.

Because many of the coals retained far too much sulfur even after second-stage flotation treatment, it was concluded that these midwestern coals are more difficult to desulfurize by flotation than are the Appalachian coals tested in earlier Bureau experiments.

INTRODUCTION

Until now, nearly all flotation-desulfurization work with the Bureau of Mines coal-pyrite flotation process has been done with easily floated coals from deep-mining operations in the Appalachian region of the United States. It has been established that many of these coals liberate their pyrite well and are floatable with only small amounts of frother reagents; thus, they are easier to desulfurize by the coal-pyrite flotation technique described in earlier Bureau of Mines publications.³

¹The work described in this report was performed by a component of the Bureau of Mines that was transferred to the Department of Energy on October 1, 1977.

²Supervisory physical science technician, Coal Preparation and Analyses Laboratory, Bureau of Mines, Pittsburgh, Pa.

³Miller, K. J. Flotation of Pyrite From Coal: Pilot Plant Study. BuMines RI 7822, 1973, 15 pp.

Miller, K. J., and A. F. Baker. Flotation of Pyrite From Coal. BuMines TPR 51, 1972, 7 pp.

It has never been firmly established, however, that less floatable coals containing finely disseminated pyrite cannot also be substantially lowered in sulfur content by using this technique. It is the purpose of this work to determine the viability of the Bureau of Mines coal-pyrite flotation method to remove pyritic sulfur from these refractory coals.

TEST PROCEDURE

Each of the run-of-mine coal samples used in the flotation tests given in this report was dried at ambient temperature and pulverized to minus 35 mesh through a hammer mill. The dry, fine-size coal was then riffled into 200-gram samples for the laboratory batch-flotation tests. A centrifugal float-sink analysis of each of the coals was done at specific gravity 1.60 (table 1).

All flotation tests were run in a conventional laboratory-size flotation cell. For each test, a 200-gram sample of coal was mixed with 2,300 milliliters of tapwater and conditioned for 15 minutes at 1,800 rev/min. The pH of the various slurries ranged from slightly below 6 to about 8. The coal flotation collector (kerosine) and the frother (MIBC) were then added to the pulp, air was supplied, and the resultant coal froth concentrate was scraped into a receiving pan until it was barren of coal (about 1 minute). Of the two reagents, the kerosine was always added first. Each of the reagents was conditioned in the pulp for 1 minute prior to the addition of air. The product (clean coal froth concentrate) was repulped in fresh tapwater in the flotation cell for second-stage treatment.

Two second-stage flotation procedures were employed: the Bureau's coal-pyrite flotation procedure and second-stage coal flotation. Before second-stage coal-pyrite flotation, the pulp pH was adjusted to about 6.0 with sulfuric acid according to procedures found most effective in earlier work.⁴ When the pulp pH was already 6.0 or lower, no pH adjustment was made. Following pH reduction, a commercial coal depressant (Aero Depressant 633 from American Cyanamid Co.⁵), a sulfide collector (potassium amyl xanthate), and a small quantity of MIBC were added to float the pyritic refuse. For second-stage coal flotation, MIBC alone was added. Each of the reagents was conditioned in the pulp for 1 minute. After reagent conditioning, air was supplied and the froth was removed for 1 minute. The final products obtained from the coal-pyrite and rougher-cleaner coal flotation tests were oven dried and analyzed for ash, pyritic sulfur, and total sulfur content.

⁴Baker, A. F., K. J. Miller, and A. W. Deurbrouck. Two-State Flotation Selectivity Floats Pyrite From Coal. *Coal Mining and Processing*, v. 10, No. 8, August 1973, pp. 44-46, 56.

⁵Reference to specific brands does not imply endorsement by the Bureau of Mines.

TABLE 1. - Centrifugal float-sink analysis of the coal samples used in the flotation experiments, percent

Specific gravity fraction	Weight	Ash	Pyritic sulfur	Total sulfur
SAMPLE A, NOS. 9 AND 14 SEAMS, COLONIAL MINE, HOPKINS COUNTY, KY.				
Float-1.60.....	85.5	7.8	1.43	2.71
1.60-sink.....	14.5	54.7	16.40	17.98
Total.....	100.0	14.6	3.60	4.92
SAMPLE B, NOS. 9 AND 14 SEAMS, COLONIAL MINE, HOPKINS COUNTY, KY.				
Float-1.60.....	84.2	7.7	0.89	2.72
1.60-sink.....	15.8	66.6	11.99	12.89
Total.....	100.0	17.0	2.64	4.33
NO. 9 SEAM, ISLAND CREEK NO. 9 MINE, HOPKINS COUNTY, KY.				
Float-1.60.....	82.7	7.8	0.88	2.75
1.60-sink.....	17.3	67.9	12.03	12.84
Total.....	100.0	18.2	2.81	4.50
NO. 9 SEAM, CAMP NO. 1 MINE, UNION COUNTY, KY.				
Float-1.60.....	81.4	8.1	0.60	2.65
1.60-sink.....	18.6	71.9	8.70	8.95
Total.....	100.0	20.0	2.41	3.82
NO. 9 SEAM, CAMP NO. 2 MINE, UNION COUNTY, KY.				
Float-1.60.....	77.3	8.0	0.70	2.62
1.60-sink.....	22.7	73.9	10.23	10.41
Total.....	100.0	23.0	2.86	4.38
NO. 9 SEAM, PROVIDENCE NO. 1 MINE, WEBSTER COUNTY, KY.				
Float-1.60.....	78.7	7.9	0.68	2.66
1.60-sink.....	21.3	69.9	10.82	11.34
Total.....	100.0	21.1	2.84	4.51
NOS. 5, 11, AND 12 SEAMS, PERFECT CIRCLE MINE, MUHLENBERG COUNTY, KY.				
Float-1.60.....	87.1	9.0	0.75	2.61
1.60-sink.....	12.9	71.4	12.49	13.05
Total.....	100.0	17.0	2.26	3.95
OPDYKE SEAM, EADS MINE, JEFFERSON COUNTY, ILL.				
Float-1.60.....	82.7	9.8	1.65	3.17
1.60-sink.....	17.3	53.7	11.24	12.65
Total.....	100.0	17.4	3.31	4.81
NO. 6 SEAM, OLD BEN NO. 24 MINE, FRANKLIN COUNTY, ILL.				
Float-1.60.....	79.4	7.5	0.57	1.86
1.60-sink.....	20.6	75.5	9.73	9.73
Total.....	100.0	21.5	2.46	3.48

FLOTATION TEST RESULTS

In the coal-pyrite flotation tests (table 2), the maximum pyritic sulfur reduction ranged from 33.4 percent (Opdyke seam, Eads mine, Jefferson County, Ill.) to 69.6 percent (No. 6 seam, Old Ben No. 24 mine, Franklin County, Ill.). This compares with a maximum pyritic sulfur reduction of 70 to 90 percent with several Appalachian coals used in earlier work.⁶ The maximum total sulfur reduction for the midwestern coals ranged from 21.2 to 43.0 percent, compared with 40 to 70 percent for the Appalachian coals. The greatest pyritic sulfur reduction from first-stage flotation alone was 43.6 percent (No. 6 seam, Old Ben No. 24 mine, Franklin County, Ill.). The pyritic sulfur reduction after two stages of flotation was 69.2 percent. More commonly, first-stage flotation accounted for less than one-half and sometimes less than one-third of the pyritic sulfur reduction obtained in a given two-stage coal-pyrite flotation test. As shown in table 3, the ratios of the average pyritic sulfur to total sulfur content (2.88:4.34 for the midwestern coals and 2.02:2.64 for the Appalachian coals) reflects the higher organic sulfur content of the midwestern coal samples. The pyritic sulfur reduction for midwestern coals averaged over 20 percentage points lower than that for Appalachian coals. This is probably due in part to such factors as the size consist, degree of liberation, or other physical characteristics of the pyrite or marcasite in the midwestern coals. Also revealed in table 3 is the greater difference between the pyritic sulfur reduction and the total sulfur reduction with the midwestern region coals, which again reflects the higher organic sulfur content.

Table 4 shows results obtained by rougher-cleaner coal flotation with some of the coals. In these tests, the maximum pyritic sulfur reductions ranged from 15.6 to 51.0 percent, substantially less than those in table 2. It is obvious that the selectivity of the pyrite removal was superior with the Bureau's coal-pyrite flotation process. However, rougher-cleaner coal flotation, if applicable, has several distinct advantages: lower reagent cost, greater ash reduction, and the production of a more concentrated, and thus more economically dewatered, clean coal product.

⁶Baker, A. F., K. J. Miller, and A. W. Deurbrouck. Desulfurization of Coal by Froth Flotation. Internat. Coal Preparation Cong., Paris, March 1973, Paper 27E, 13 pp.; available for consultation at Bureau of Mines Coal Preparation and Analysis Laboratory, Bruceton, Pa.

TABLE 2. - Two-stage flotation employing the Bureau of Mines second-stage coal-pyrite flotation process

Reagents	Product	Percent					
		Weight	Ash	Pyritic sulfur	Total sulfur	Sulfur reduction	
						Pyritic	Total
<u>SAMPLE A, NOS. 9 AND 14 SEAMS, COLONIAL MINE, HOPKINS COUNTY, KY.</u>							
<u>First stage</u>							
Kerosine, 2.0 lb/ton MIBC, 0.25 lb/ton	Clean coal 2....	79.3	10.0	2.04	3.72	43.8	26.2
	Reject 2.....	10.2	19.6	11.12	11.31	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.5 lb/ton Potassium amyl xanthate, 0.5 lb/ton MIBC, 0.1 lb/ton	Clean coal 1....	89.5	11.1	3.07	4.59	15.4	8.9
	Reject 1.....	10.5	49.4	8.39	8.90	-	-
	Feed.....	100.0	15.1	3.63	5.04	-	-
<u>First stage</u>							
Kerosine, 2.0 lb/ton MIBC, 0.25 lb/ton	Clean coal 2....	79.0	10.2	1.98	3.63	45.8	27.3
	Reject 2.....	11.6	21.7	11.85	11.85	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton Potassium amyl xanthate, 0.5 lb/ton MIBC, 0.1 lb/ton	Clean coal 1....	90.6	11.7	3.24	4.68	11.2	6.2
	Reject 1.....	9.4	47.7	7.58	8.00	-	-
	Feed.....	100.0	15.1	3.65	4.99	-	-
<u>SAMPLE B, NOS. 9 AND 14 SEAMS, COLONIAL MINE, HOPKINS COUNTY, KY.</u>							
<u>First stage</u>							
Kerosine, 2.0 lb/ton MIBC, 0.5 lb/ton	Clean coal 2 ...	78.1	10.6	1.46	3.41	43.9	21.8
	Reject 2.....	8.2	16.3	8.15	9.24	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.5 lb/ton Potassium amyl xanthate, 0.4 lb/ton MIBC, 0.1 lb/ton	Clean coal 1....	86.3	11.1	2.10	3.96	19.2	9.2
	Reject 1.....	13.7	68.1	5.80	6.84	-	-
	Feed.....	100.0	18.9	2.60	4.36	-	-
<u>First stage</u>							
Kerosine, 2.0 lb/ton MIBC, 0.5 lb/ton	Clean coal 2....	78.8	9.4	1.51	3.36	47.9	26.3
	Reject 2.....	8.8	20.6	10.46	12.48	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton Potassium amyl xanthate, 0.5 lb/ton MIBC, 0.1 lb/ton	Clean coal 1....	87.6	10.5	2.41	4.28	16.9	6.1
	Reject 1.....	12.4	70.0	6.38	6.54	-	-
	Feed.....	100.0	17.9	2.90	4.56	-	-
<u>NO. 9 SEAM, ISLAND CREEK NO. 9 MINE, HOPKINS COUNTY, KY.</u>							
<u>First stage</u>							
Kerosine, 1.0 lb/ton MIBC, 0.25 lb/ton	Clean coal 2....	72.6	9.7	1.23	2.95	59.7	33.4
	Reject 2.....	12.1	20.4	10.48	11.37	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton Potassium amyl xanthate, 0.5 lb/ton MIBC, 0.1 lb/ton	Clean coal 1....	84.7	11.2	2.55	4.15	16.4	6.3
	Reject 1.....	15.3	67.1	5.81	5.96	-	-
	Feed.....	100.0	19.8	3.05	4.43	-	-
<u>First stage</u>							
Kerosine, 1.0 lb/ton MIBC, 0.25 lb/ton	Clean coal 2....	71.6	9.9	1.23	2.95	57.3	34.4
	Reject 2.....	13.1	19.3	8.72	11.23	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton Potassium amyl xanthate, 0.6 lb/ton MIBC, 0.1 lb/ton	Clean coal 1....	84.7	11.4	2.39	4.23	17.0	6.0
	Reject 1.....	15.3	68.1	5.63	5.96	-	-
	Feed.....	100.0	20.0	2.88	4.50	-	-
<u>NO. 9 SEAM, CAMP NO. 1 MINE, UNION COUNTY, KY.</u>							
<u>First stage</u>							
Kerosine, 1.0 lb/ton MIBC, 0.5 lb/ton	Clean coal 2....	72.5	9.5	0.88	2.72	64.1	31.7
	Reject 2.....	9.6	18.3	7.01	9.05	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton Potassium amyl xanthate, 0.5 lb/ton MIBC, 0.1 lb/ton	Clean coal 1....	82.1	10.5	1.60	3.46	34.7	13.1
	Reject 1.....	17.9	70.4	6.34	6.34	-	-
	Feed.....	100.0	21.3	2.45	3.98	-	-

TABLE 2. - Two-stage flotation employing the Bureau of Mines second-stage coal-pyrite flotation process--Continued

Reagents	Product	Percent					
		Weight	Ash	Pyritic sulfur	Total sulfur	Sulfur reduction	
						Pyritic	Total
NO. 9 SEAM, CAMP NO. 2 MINE, UNION COUNTY, KY.							
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	65.2	10.5	1.11	3.04	62.1	30.0
MIBC, 0.5 lb/ton		Reject 2.....	11.7	17.4	6.42	7.72	-
<u>Second stage</u>							
Aero Depressant 633, 0.5 lb/ton	Clean coal 1....	76.9	11.6	1.92	3.75	34.5	13.6
Potassium amyl xanthate, 0.5 lb/ton		Reject 1.....	23.1	72.3	6.30	6.30	-
MIBC, 0.1 lb/ton	Feed.....	100.0	25.6	2.93	4.34	-	-
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	69.1	10.8	1.26	3.11	55.3	26.7
MIBC, 0.5 lb/ton		Reject 2.....	8.8	18.8	7.01	8.64	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton	Clean coal 1....	77.9	11.7	1.91	3.73	32.3	12.0
Potassium amyl xanthate, 0.5 lb/ton		Reject 1.....	22.1	72.7	6.02	6.02	-
MIBC, 0.1 lb/ton	Feed.....	100.0	25.2	2.82	4.24	-	-
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	68.1	9.8	1.24	3.07	59.7	31.5
MIBC, 0.5 lb/ton		Reject 2.....	11.1	18.7	7.01	8.23	-
<u>Second stage</u>							
Aero Depressant 633, 0.8 lb/ton	Clean coal 1....	79.2	11.1	2.05	3.79	33.4	15.4
Potassium amyl xanthate, 0.7 lb/ton		Reject 1.....	20.8	71.5	7.03	7.10	-
MIBC, 0.1 lb/ton	Feed.....	100.0	23.6	3.08	4.48	-	-
NO. 9 SEAM, PROVIDENCE NO. 1 MINE, WEBSTER COUNTY, KY.							
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	73.4	10.1	1.28	3.35	55.4	29.3
MIBC, 0.25 lb/ton		Reject 2.....	9.1	17.7	8.18	9.69	-
<u>Second stage</u>							
Aero Depressant 633, 0.5 lb/ton	Clean coal 1....	82.5	10.9	2.04	4.05	28.9	14.6
Potassium amyl xanthate, 0.5 lb/ton		Reject 1.....	17.5	73.0	6.78	7.99	-
MIBC, 0.1 lb/ton	Feed.....	100.0	21.8	2.87	4.74	-	-
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	70.7	9.2	1.04	2.92	64.8	36.5
MIBC, 0.25 lb/ton		Reject 2.....	9.7	17.6	7.91	9.59	-
<u>Second stage</u>							
Aero Depressant 633, 0.8 lb/ton	Clean coal 1....	80.4	10.2	1.87	3.72	36.6	19.1
Potassium amyl xanthate, 0.7 lb/ton		Reject 1.....	19.6	66.6	7.40	8.21	-
MIBC, 0.1 lb/ton	Feed.....	100.0	21.3	2.95	4.60	-	-
NOS. 6, 11, AND 12 SEAMS, PERFECT CIRCLE MINE, MUHLENBERG COUNTY, KY.							
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	58.1	8.5	0.88	2.56	64.2	35.0
MIBC, 0.5 lb/ton		Reject 2.....	11.7	15.3	5.49	6.92	-
<u>Second stage</u>							
Aero Depressant 633, 0.5 lb/ton	Clean coal 1....	69.8	9.6	1.65	3.29	32.9	16.5
Potassium amyl xanthate, 0.5 lb/ton		Reject 1.....	30.2	40.0	4.33	5.44	-
MIBC, 0.1 lb/ton	Feed.....	100.0	18.8	2.46	3.94	-	-
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	59.1	8.5	0.88	2.68	64.4	33.8
MIBC, 0.5 lb/ton		Reject 2.....	10.0	16.9	6.42	7.85	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton	Clean coal 1....	69.1	9.7	1.68	3.43	32.0	15.3
Potassium amyl xanthate, 0.5 lb/ton		Reject 1.....	30.9	40.0	4.22	5.43	-
MIBC, 0.1 lb/ton	Feed.....	100.0	19.1	2.47	4.05	-	-

TABLE 2. - Two-stage flotation employing the Bureau of Mines second-stage coal-pyrite flotation process--Continued

Reagents	Product	Percent					
		Weight	Ash	Pyritic sulfur	Total sulfur	Sulfur reduction	
						Pyritic	Total
<u>NOS. 6, 11, AND 12 SEAMS, PERFECT CIRCLE MINE, MUHLENBERG COUNTY, KY.--Continued</u>							
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	59.3	8.4	0.88	2.68	65.6	34.0
MIBC, 0.5 lb/ton	Reject 2.....	9.0	15.8	5.54	7.30	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.8 lb/ton	Clean coal 1....	68.3	9.4	1.49	3.29	41.8	19.0
Potassium amyl xanthate, 0.7 lb/ton	Reject 1.....	31.7	41.1	4.85	5.72	-	-
MIBC, 0.1 lb/ton	Feed.....	100.0	19.4	2.56	4.06	-	-
<u>OPDYKE SEAM, EADS MINE, JEFFERSON COUNTY, ILL.</u>							
<u>First stage</u>							
Kerosine, 2.0 lb/ton	Clean coal 2....	72.4	12.8	2.40	3.99	28.4	18.7
MIBC, 0.5 lb/ton	Reject 2.....	8.7	19.3	8.78	10.23	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.5 lb/ton	Clean coal 1....	81.1	13.5	3.08	4.66	8.1	5.1
Potassium amyl xanthate, 0.5 lb/ton	Reject 1.....	18.9	37.4	4.51	5.96	-	-
MIBC, 0.1 lb/ton	Feed.....	100.0	18.0	3.35	4.91	-	-
<u>First stage</u>							
Kerosine, 2.0 lb/ton	Clean coal 2....	75.4	13.4	2.29	3.80	33.4	21.2
MIBC, 0.5 lb/ton	Reject 2.....	11.1	19.1	8.61	9.80	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton	Clean coal 1....	86.5	14.1	3.10	4.57	9.9	5.2
Potassium amyl xanthate, 0.5 lb/ton	Reject 1.....	13.5	47.1	5.61	6.40	-	-
MIBC, 0.1 lb/ton	Feed.....	100.0	18.6	3.44	4.82	-	-
<u>NO. 6 SEAM, OLD BEN NO. 24 MINE, FRANKLIN COUNTY, ILL.</u>							
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	67.5	9.1	0.82	2.11	66.8	40.7
MIBC, 0.25 lb/ton	Reject 2.....	7.9	16.0	7.01	7.50	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.5 lb/ton	Clean coal 1....	75.4	9.8	1.47	2.67	40.5	25.0
Potassium amyl xanthate, 0.5 lb/ton	Reject 1.....	24.6	60.4	5.53	6.27	-	-
MIBC, 0.1 lb/ton	Feed.....	100.0	22.3	2.47	3.56	-	-
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	67.6	9.3	0.77	2.14	69.2	40.2
MIBC, 0.25 lb/ton	Reject 2.....	7.8	18.0	7.00	8.59	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.7 lb/ton	Clean coal 1....	75.4	10.2	1.41	2.81	43.6	21.5
Potassium amyl xanthate, 0.5 lb/ton	Reject 1.....	24.6	61.4	5.81	5.93	-	-
MIBC, 0.1 lb/ton	Feed.....	100.0	22.8	2.50	3.58	-	-
<u>First stage</u>							
Kerosine, 1.0 lb/ton	Clean coal 2....	65.4	9.7	0.76	2.12	69.6	43.0
MIBC, 0.25 lb/ton	Reject 2.....	10.9	18.7	7.60	8.76	-	-
<u>Second stage</u>							
Aero Depressant 633, 0.8 lb/ton	Clean coal 1....	76.3	11.0	1.74	3.07	30.4	17.5
Potassium amyl xanthate, 0.7 lb/ton	Reject 1.....	23.7	62.7	4.94	5.80	-	-
MIBC, 0.1 lb/ton	Feed.....	100.0	23.2	2.50	3.72	-	-

TABLE 3. - Ratio of average pyritic sulfur to the total sulfur content of a number of midwestern and Appalachian region coals, and the average pyritic and total sulfur reduction obtained by coal-pyritic flotation, percent

Region	Ratio, pyritic sulfur to total sulfur	Pyritic sulfur reduction	Total sulfur reduction
Midwestern.....	2.88:4.34	53.1	31.1
Appalachian.....	2.02:2.64	73.3	56.1

TABLE 4. - Two-stage rougher-cleaner coal flotation, percent

Reagents	Product	Percent					
		Weight	Ash	Pyritic sulfur	Total sulfur	Sulfur reduction	
						Pyritic	Total
SAMPLE A, NOS. 9 AND 14 SEAMS, COLONIAL MINE, HOPKINS COUNTY, KY.							
First stage Kerosine, 2.0 lb/ton MIBC, 0.25 lb/ton	Clean coal 2.	87.0	10.2	2.96	4.35	16.4	10.9
	Reject 2.....	5.1	31.3	6.90	8.24	-	-
Second stage MIBC, 0.1 lb/ton	Clean coal 1.	92.1	11.4	3.18	4.57	10.2	6.4
	Reject 1.....	7.9	50.9	7.74	8.49	-	-
	Feed....	100.0	14.5	3.54	4.88	-	-
SAMPLE B, NOS. 9 AND 14 SEAMS, COLONIAL MINE, HOPKINS COUNTY, KY.							
First stage Kerosine, 2.0 lb/ton MIBC, 0.5 lb/ton	Clean coal 2.	77.8	7.9	1.98	3.51	34.2	19.3
	Reject 2.....	7.7	29.5	5.93	7.30	-	-
Second stage MIBC, 0.1 lb/ton	Clean coal 1.	85.5	9.9	2.34	3.85	22.3	11.5
	Reject 1.....	14.5	67.0	7.02	7.27	-	-
	Feed....	100.0	18.1	3.01	4.35	-	-
NO. 9 SEAM, PROVIDENCE NO. 1 MINE, WEBSTER COUNTY, KY.							
First stage Kerosine, 1.0 lb/ton MIBC, 0.25 lb/ton	Clean coal 2.	72.0	7.0	1.56	3.44	48.6	24.6
	Reject 2.....	8.5	21.5	4.79	6.74	-	-
Second stage MIBC, 0.1 lb/ton	Clean coal 1.	80.5	8.5	1.81	3.79	36.3	16.9
	Reject 1.....	19.5	68.1	7.08	7.77	-	-
	Feed....	100.0	20.2	2.84	4.56	-	-
NOS. 6, 11, AND 12 SEAMS, PERFECT CIRCLE MINE, MUHLENBERG COUNTY, KY.							
First stage Kerosine, 1.0 lb/ton MIBC, 0.5 lb/ton	Clean coal 2.	64.2	7.2	1.23	3.02	51.0	24.5
	Reject 2.....	9.1	24.4	3.58	4.54	-	-
Second stage MIBC, 0.1 lb/ton	Clean coal 1.	73.3	9.3	1.52	3.21	39.4	19.8
	Reject 1.....	26.7	40.2	5.21	6.19	-	-
	Feed....	100.0	17.6	2.51	4.00	-	-
OPDYKE SEAM, EADS MINE, JEFFERSON COUNTY, ILL.							
First stage Kerosine, 2.0 lb/ton MIBC, 0.5 lb/ton	Clean coal 2.	73.3	12.1	2.86	4.57	15.6	7.5
	Reject 2.....	12.7	23.6	3.92	5.30	-	-
Second stage MIBC, 0.1 lb/ton	Clean coal 1.	86.0	13.8	3.02	4.68	10.9	5.3
	Reject 1.....	14.0	43.2	5.67	6.53	-	-
	Feed....	100.0	17.9	3.39	4.94	-	-

Figure 1 correlates the pyritic sulfur reduction obtained by laboratory centrifugal float-sink analysis with the maximum obtained by coal-pyrite and rougher-cleaner flotation. Clearly, the pyritic sulfur reduction follows the same general pattern in each case. The pyritic sulfur reduction obtained by

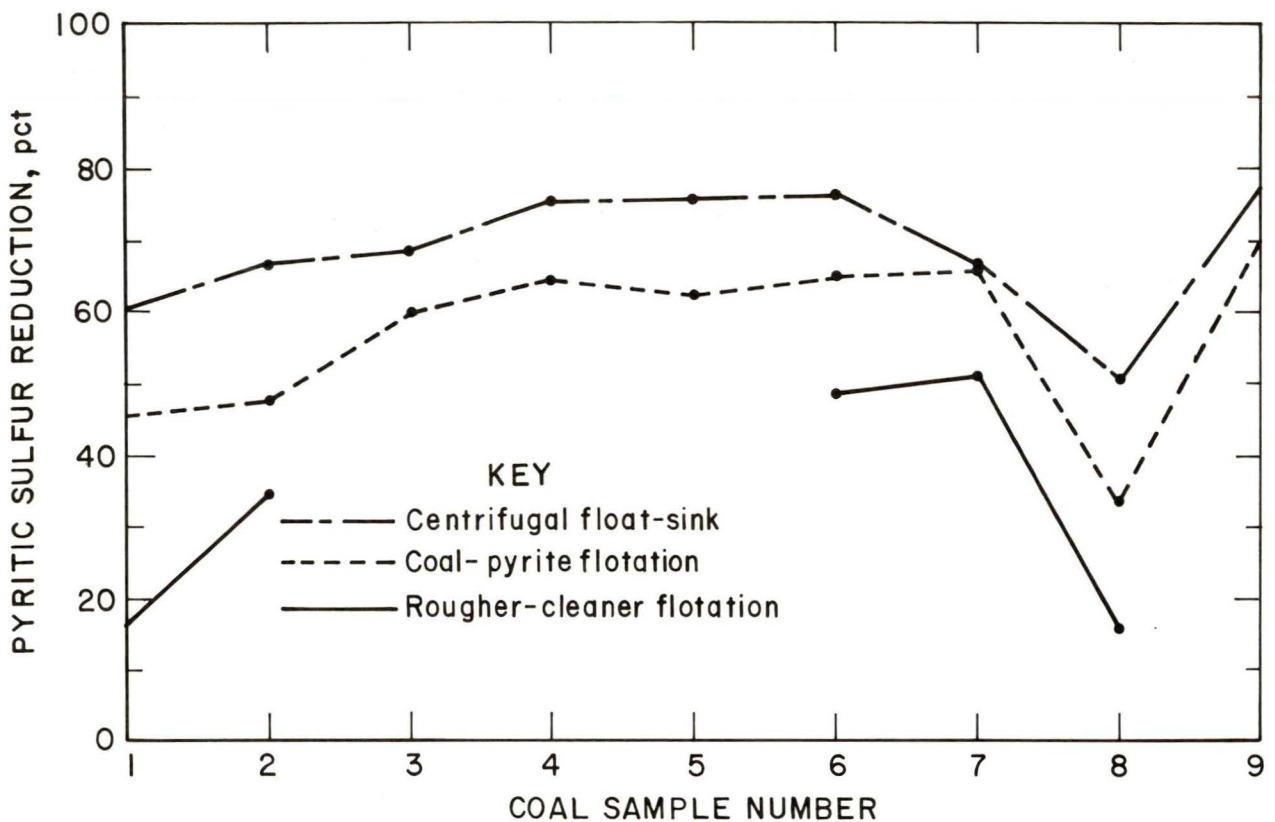


FIGURE 1. - Pyritic sulfur reduction of the nine midwestern region coals by float-sink, coal-pyrite flotation, and rougher-cleaner flotation.

float-sink analysis is consistently greater because the float-sink method used is a laboratory analytical procedure employing a centrifuge and heavy organic liquids under rather precise conditions; thus, it cannot be equated directly with a commercial fine-coal-washing technique such as froth flotation. The purpose of the float-sink data in this report is to show the maximum pyritic sulfur reduction that could be expected by flotation with these coals at this size consist. Greater pyrite liberation, and thus greater sulfur reduction, could probably be obtained with these test coals by carefully grinding the coal to an overall size finer than minus 35 mesh prior to flotation. However, such a detailed study involving stage grinding of each of the coal samples was beyond the scope of this short-term study.

CONCLUSIONS

The coals tested from the midwestern region are more difficult to desulfurize by flotation than many higher rank, deep-mined coals of the same general size consist from the Appalachian region. This difficulty is due to such factors as the relatively high organic-sulfur content of the coals and perhaps certain physical characteristics of the pyrite or marcasite (such as the size consist and the degree of liberation).

Despite the aforementioned limitations to physical desulfurization, pyritic sulfur reductions of nearly 70 percent can be obtained with some of the test coals using the Bureau's two-stage coal-pyrite flotation process. On the other hand, the maximum pyritic sulfur reduction obtainable by rougher-cleaner coal flotation is about 50 percent.

It can be concluded that pyritic sulfur is more selectively removed using the Bureau of Mines coal-pyrite flotation process than by rougher-cleaner coal flotation.

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