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SURFACE MAGNETIC ENHANCEMENT FOR COAL CLEANING

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SUMMARY AND FUTURE WORK

The fundamental chemistry for selective adsorption of magnetizing reagent on coal-associated minerals to enhance the magnetic susceptibilities of minerals have been established in Phase I study. The application of the results on coal cleaning for the Phase II study is completed this quarter. Illinois No. 6, Ohio Lower Kittanning, and West Virginia Pocahontas coals have been investigated to determine the most effective way of using the magnetizing method for coal cleaning. The results show that the best separation performance is obtained on finely ground coals. Up to 91% ash reduction (from 22% to 3.3% ash content) and 93% pyritic sulfur reduction at 70% BTU recovery can be obtained with the magnetizing approach when Illinois No. 6 coal is processed at 90% passing 500 mesh. Even at a coarser sizes such as 90% passing 200 mesh, 86% ash reduction and 87% pyritic sulfur reduction with 74% coal BTU recovery can still be obtained. Similar results are obtained for Lower Kittanning and Pocahontas coal.

In the next quarter, the Phase III study will be conducted to examine the separator parameters.

INTRODUCTION

This research studies the surface enhancement of magnetic susceptibility of minerals for coal cleaning. The enhancement is achieved by adsorbing magnetizing reagent on minerals. The objectives of the study include: (i) to define the optimal conditions for adsorption selectivity and magnetic enhancement using magnetizing reagent approach, (ii) to determine the effect of such magnetic enhancement on the coal cleaning efficiency with magnetic separations, and (iii) to evaluate where this method can be adapted to the existing coal processing schemes for maximum effectiveness.

Three phases of work are included in this research: a fundamental study, an application study, and an industrial laboratory study. The fundamental study investigates the basic chemistry involved in the interactions of magnetizing reagents and minerals. The application study employs the basic chemistry for coal cleaning under various process schemes. The work performed during this reporting period is part of the application study. Major efforts are on the process adaptation testing (Task 8), Phase II data evaluation (Task 9), and Phase II report preparation (Task 10).

PROGRESS BY WORK BREAKDOWN STRUCTURE

Task 1. Magnetizing Reagent Preparation

Thirty five magnetizing reagents with various surfactant functional groups have been prepared for this study. The properties of these reagents were documented in the previous reports. Five reagents, selected from

different cationic, anionic, and nonionic categories, were investigated for their shelf life. The results show that magnetizing reagents are stable for long term storage. This task is completed.

Task 2. Mineral/Reagent Interactions

The interactions of magnetizing reagents and minerals under various conditions have been investigated. The conditions include pH, kinds and dosages of magnetizing reagents, mineral activator, coal depressant, oxidation effect, and slurry regulators. All of the experimental results have been described in the previous reports. This task is completed.

Task 3. Magnetite Size Effect

The particle size of magnetite and its effects on the properties of magnetizing reagents were studied. The experiments show that smaller magnetite particles provide better metallurgical results. This task is completed.

Task 4. Phase I Data Evaluation

All of the results in Phase I study have been evaluated. The most promising conditions for selective magnetic enhancement of coal-associated minerals have been selected.

Task 5. Phase I Report and Review

The reports documenting the progress in Phase I study have been completed and reviewed.

Task 6. Coal Selection, Preparation, and Characterization

Three coals are selected for the Phase II study. They are Illinois No. 6, Ohio Lower Kittanning, and West Virginia Pocahontas No. 3 seams. Each 400 pound sample was prepared simulating the commercial operations to yield the feed for this study. The circuits include heavy media, tabling, and froth flotation separations. Characterization study includes coal

analysis, grindability, washability, mineralogy, and maceral and pyrite distributions. The results were described in the previous reports. This task is completed.

Task 7. Optimization of Magnetizing Conditions

Eleven promising conditions to yield selective adsorption of magnetizing reagent on coal-associated minerals have been evaluated on the basis of magnetic separations. The three coals at -48 mesh prepared in Task 6 were utilized in these tests. The results show that enhanced separation is particularly successful with an approach which uses a hydrophillic modifier for coal depressing and a cationic magnetizing reagent for mineral magnetic enhancement. A reduction of 92% ash and 83% pyrite can be achieved. In addition, flotation concentrates of these coals at -48 mesh were also examined with this approach. The results show that the magnetic enhancement approach performs better than the recleaning flotation approach. At the same extent of pyrite reduction, the magnetic enhancement approach gains 12% additional coal yield than the recleaning flotation approach does for Illinois No. 6 coal. The better selectivity on removing the unliberated pyrite from coal particles is believed the reason. This task is completed.

Task 8. Process Adaptation Testing

This task is to determine the best way to adopt the magnetizing method to the existing coal preparation and utilization scenarios. Three options are included. The first option is to condition the coal concentrates with the magnetizing reagent at the preparation plant, dry pulverize the coal at power plant, and conduct dry magnetic separation before combustion. The second option is to process the preparation plant middlings. The third option is in the area of fine coal cleaning, which is found most promising.

Option 1.1. Table Concentrate Processing. Experiments show that adsorbed magnetic reagent is not smeared away from mineral surface during pulverizing. Wet magnetic separation can remove residual pyrite and ash effectively, but dry magnetic separation is ineffective.

Option 1.2. Heavy Media Concentrate Processing. Experimental results agree with Option 1.1 that only wet magnetic separation is effective.

Option 1.3. Flotation Concentrate Processing. Dry magnetic separation is still ineffective.

Option 2. Heavy Media Middlings Processing. The middlings are very difficult to liberate. The concentrate obtained from the middlings after processing contains higher ash content than that obtained from processing the ROM coals directly.

Option 3.1. Fine Coal Processing for Illinois No. 6. Ash content reduced from 22% to 3.3% with 70% coal recovery can be obtained. Similar separation results are obtained in the range of 90% passing 200 mesh to 90% passing 500 mesh.

Option 3.2. Fine Coal Processing for Lower Kittanning. Ash content can be reduced from 6.9% to 1.3% at 79% coal recovery. The effect of particle sizes in the range of 90% passing 200 mesh to 90% passing 500 mesh on magnetic enhanced separation is not significant.

Option 3.3. Fine Coal Processing for Pocahontas. Pocahontas ROM coal was processed during this reporting period using the same procedures established earlier. The results of separation at 90% passing 500 mesh are shown in Table 1 by varying the reagent dosages, and in Table 2 by varying the magnetic field strengths. The ash content can be reduced from about 30% to about 5% (90% ash rejection) at about 59% yield (80% coal recovery). The retention time is about 3 seconds. With the increase of retention time, it

is possible to reduce the reagent dosage and the magnetic field strength and to obtain products with lower ash contents.

At 90% passing 325 mesh, the separation results at various reagent dosages and magnetic field strengths are shown in Table 3 and 4, respectively. Ash can be reduced to about the same extent as at 90% passing 500 mesh, although coal yield is slightly lower. Reagent dosage and applied magnetic field strength are again related to the retention time. At the short retention time in these tests (about 3 seconds in total), reagent dosage and field strength need to be high. However, the separation results at lower field strength and reagent dosage generally follow the same separation curve obtained at higher field strength and reagent dosage. Therefore, the determination of optimum reagent dosage and magnetic field strength should rely on the selection of retention time.

Tables 5 and 6 show the separation results at 90% passing 200 mesh. Tables 7 and 8 show the results at 90% passing 100 mesh. The effects of magnetic field strength and reagent dosage on separation remain the same as that for the finer particle size.

Figure 1 demonstrates the effects of particle sizes on the ash contents and coal recovery using the magnetizing reagent approach. The improvement of separation with the reduction of particle size is obvious.

Sulfur Reduction and BTU Recovery. A critical evaluation of the magnetizing reagent approach should also be on its ability to remove pyritic sulfur at high BTU recovery. Large amounts of samples were processed to generate sufficient materials for complete analysis. The conditions of processing are those which have been shown effective on ash reduction earlier.

The results for processing Illinois No. 6 ROM coal at various particle sizes are shown in Table 9. At 90% passing 500 mesh, about 93% pyritic sulfur is removed with 68% BTU recovery. The separation efficiency (BTU recovery - (100 - pyritic sulfur rejection)) is 61.7%. The results at 90% passing 325 mesh and 200 mesh particle sizes are similar to that at 90% passing 500 mesh. The slight increase in pyritic sulfur content of the products is accompanied with the increase in BTU recovery. The separation efficiency is not changed significantly. At 90% passing 100 mesh, the BTU recovery is reduced in large amounts. This reduction is assumed to be the result of mechanical entrapment of large coal particles in the wool matrix of the separator.

Lower Kittanning and Pocahontas coals can also be well cleaned with the magnetizing reagent approach, as shown in Tables 10 and 11. About 81% pyritic sulfur are removed from Lower Kittanning coal at 85% BTU recovery. The Pocahontas coal concentrate contains only 0.07% pyritic sulfur, which is 93% pyritic sulfur rejection. The BTU recovery is about 58%, probably due to the mechanical entrapment of coal particles in the magnetic fractions. The ash content of this coal is very high. The collection of the large amount of mineral particles will inevitably entrap a significant fraction of coal particles through the crowding effect.

Task 9. Phase II Data Evaluation

All of the results in Phase II study have been evaluated. The most promising approach to adopt the magnetic reagent technology on coal cleaning is in the fine coal cleaning area.

Task 10. Phase II Report and Review

The reports documenting the results in Phase II study have been completed.

Figure 1

Table 1. Reagent dosage effect on the separation of
Pocahontas R.O.M. coal at 90% passing 500 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifier (lb/t)	Reagent (lb/t)
1-C	77.15	77.15	23.90	23.90	36.95	82.98	5.00	2.50
T3	4.77	81.92	40.44	24.86	30.35	86.99		
T2	10.35	92.27	47.03	27.35	13.72	94.74		
T1	7.73	100.00	51.86	29.25				
	100.00		29.25					
2-C	71.90	71.90	24.07	24.07	41.78	77.69	10.00	5.00
T3	4.86	76.76	41.06	25.15	35.06	81.76		
T2	8.90	85.66	42.78	26.98	22.26	89.01		
T1	14.34	100.00	46.13	29.72				
	100.00		29.72					
3-C	65.64	65.64	12.43	12.43	72.72	82.00	20.00	10.00
T3	4.49	70.13	59.19	15.43	63.83	84.62		
T2	7.93	78.06	63.54	20.31	46.99	88.74		
T1	21.94	100.00	64.04	29.91				
	100.00		29.91					
4-C	59.22	59.22	5.14	5.14	89.68	79.67	40.00	20.00
T3	3.82	63.03	53.01	8.04	82.82	82.21		
T2	8.84	71.87	62.47	14.73	64.10	86.92		
T1	28.13	100.00	67.21	29.49				
	100.00		29.49					
5-C	71.60	71.60	11.95	11.95	70.49	88.78	60.00	30.00
T3	4.43	76.03	65.16	15.05	60.53	90.95		
T2	8.39	84.42	70.72	20.58	40.06	94.41		
T1	15.58	100.00	74.54	28.99				
	100.00		28.99					
6-C	78.34	78.34	15.53	15.53	56.58	91.94	80.00	40.00
T3	3.54	81.88	66.45	17.73	48.18	93.59		
T2	5.52	87.40	70.09	21.04	34.38	95.88		
T1	12.60	100.00	76.47	28.02				
	100.00		28.02					

Table 2. Magnetic field strength effect on the separation of Pocahontas R.O.M. coal at 90% passing 500 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifier (lb/t)	Reagent (lb/t)
1-C	79.26	79.26	21.40	21.40	44.41	89.66	40.00	20.00
T3	4.23	83.49	63.73	23.54	35.58	91.86	2.0 K. Gauss	
T2	5.78	89.27	64.27	26.18	23.41	94.83		
T1	10.73	100.00	66.55	30.51				
	100.00		30.51					
2-C	69.36	69.36	13.72	13.72	68.20	85.40	40.00	20.00
T3	4.70	74.06	64.64	16.95	58.05	87.77	5.0 K. Gauss	
T2	8.61	82.67	66.59	22.12	38.88	91.87		
T1	17.33	100.00	67.14	29.92				
	100.00		29.92					
3-C	65.41	65.41	10.37	10.37	77.26	83.55	40.00	20.00
T3	3.82	69.23	55.78	12.87	70.12	85.95	10.0 K. Gauss	
T2	8.52	77.75	66.90	18.80	51.01	89.97		
T1	22.25	100.00	68.38	29.83				
	100.00		29.83					
4-C	66.25	66.25	10.49	10.49	76.53	84.26	40.00	20.00
T3	3.36	69.61	57.67	12.77	69.99	86.28	15.0 K. Gauss	
T2	7.61	77.22	64.53	17.87	53.42	90.12		
T1	22.78	100.00	69.46	29.62				
	100.00		29.62					
5-C	64.73	64.73	9.33	9.33	79.86	83.84	40.00	20.00
T3	4.27	69.01	60.96	12.53	71.18	86.22	18.0 K. Gauss	
T2	7.27	76.28	66.59	17.68	55.04	89.69		
T1	23.72	100.00	69.58	29.99				
	100.00		29.99					
6-C	62.51	62.51	8.29	8.29	82.79	82.01	40.00	20.00
T3	4.64	67.14	61.53	11.97	73.31	84.57	20.0 K. Gauss	
T2	8.24	75.38	67.85	18.07	54.74	88.36		
T1	24.62	100.00	66.94	30.10				
	100.00		30.10					

Table 3. Reagent dosage effect on the separation of
Pocahontas R.O.M. coal at 90% passing 325 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifie (lb/t)	Reagent (lb/t)
1-C	74.26	74.26	23.11	23.11	42.78	81.56	5.00	2.50
T3	6.50	80.76	44.97	24.87	33.04	86.67		
T2	7.42	88.17	46.91	26.72	21.44	92.29		
T1	11.83	100.00	54.38	29.99				
	100.00		29.99					
2-C	69.85	69.85	21.35	21.35	49.97	78.26	10.00	5.00
T3	6.35	76.19	45.38	23.35	40.31	83.20		
T2	8.51	84.70	47.88	25.82	26.64	89.52		
T1	15.30	100.00	51.91	29.81				
	100.00		29.81					
3-C	63.77	63.77	10.12	10.12	78.17	81.37	20.00	10.00
T3	4.20	67.97	52.47	12.74	70.72	84.20		
T2	8.75	76.71	64.30	18.61	51.69	88.63		
T1	23.29	100.00	65.61	29.56				
	100.00		29.56					
4-C	54.03	54.03	5.24	5.24	90.48	72.86	40.00	20.00
T3	3.68	57.71	43.42	7.68	85.10	75.82		
T2	9.45	67.16	52.45	13.98	68.42	82.22		
T1	32.84	100.00	61.95	29.73				
	100.00		29.73					
5-C	72.42	72.42	11.80	11.80	69.26	88.47	60.00	30.00
T3	4.93	77.35	64.67	15.17	57.80	90.88		
T2	6.92	84.27	66.06	19.35	41.35	94.13		
T1	15.73	100.00	73.08	27.80				
	100.00		27.80					

Table 4. Magnetic field strength effect on the separation of Pocahontas R.O.M. coal at 90% passing 325 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifier (lb/t)	Reagent (lb/t)
1-C	65.83	65.83	12.81	12.81	72.82	83.22	40.00	20.00
T3	6.47	72.30	65.59	17.53	59.14	86.44	2.0 K. Gauss	
T2	8.58	80.88	66.36	22.71	40.78	90.63		
T1	19.12	100.00	66.19	31.03				
			31.03					
2-C	70.94	70.94	16.14	16.14	62.94	86.08	40.00	20.00
T3	4.37	75.31	59.39	18.65	54.54	88.65	5.0 K. Gauss	
T2	8.00	83.31	67.69	23.36	37.01	92.39		
T1	16.69	100.00	68.50	30.89				
			30.89					
3-C	68.50	68.50	15.22	15.22	66.48	84.29	40.00	20.00
T3	4.75	73.25	59.64	18.10	57.37	87.07	10.0 K. Gauss	
T2	7.79	81.04	66.50	22.75	40.71	90.86		
T1	18.96	100.00	66.78	31.10				
			31.10					
4-C	66.08	66.08	13.12	13.12	72.04	83.21	40.00	20.00
T3	4.89	70.97	59.62	16.33	62.63	86.08	15.0 K. Gauss	
T2	8.76	79.74	64.05	21.57	44.53	90.64		
T1	20.26	100.00	68.14	31.01				
			31.01					
5-C	68.63	68.63	13.84	13.84	69.10	85.37	40.00	20.00
T3	4.95	73.58	61.93	17.08	59.13	88.09	18.0 K. Gauss	
T2	6.81	80.39	64.37	21.08	44.86	91.60		
T1	19.61	100.00	70.32	30.74				
			30.74					
6-C	64.62	64.62	11.09	11.09	76.58	82.79	40.00	20.00
T3	4.21	68.83	55.91	13.83	68.89	85.47	20.0 K. Gauss	
T2	6.39	75.22	61.06	17.85	56.14	89.05		
T1	24.78	100.00	69.34	30.60				
			30.60					

Table 5. Reagent dosage effect on the separation of
Pocahontas R.O.M. coal at 90% passing 200 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifier (lb/t)	Reagent (lb/t)
1-C	64.12	64.12	12.36	12.36	73.38	80.01	10.00	5.00
T3	5.18	69.30	45.09	14.81	65.53	84.07		
T2	9.45	78.75	59.56	20.18	46.63	89.51		
T1	21.25	100.00	65.32	29.77				
			29.77					
2-C	57.56	57.56	8.54	8.54	83.75	75.48	20.00	10.00
T3	6.57	64.14	44.50	12.22	74.08	80.71		
T2	9.48	73.61	55.76	17.83	56.61	86.72		
T1	26.39	100.00	64.89	30.25				
			30.25					
3-C	47.73	47.73	4.74	4.74	92.56	65.35	40.00	20.00
T3	5.82	53.55	32.21	7.72	86.40	71.02		
T2	11.48	65.04	46.64	14.60	68.80	79.83		
T1	34.96	100.00	59.86	30.42				
			30.42					
4-C	68.68	68.68	10.99	10.99	72.52	84.29	60.00	30.00
T3	5.34	74.02	54.85	14.16	61.85	87.61		
T2	8.71	82.74	60.33	19.02	42.72	92.38		
T1	17.26	100.00	67.98	27.47				
			27.47					

Table 6. Magnetic field strength effect on the separation of
Pocahontas R.O.M. coal at 90% passing 200 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifier (lb/t)	Reagent (lb/t)
1-C	78.43	78.43	18.43	18.43	46.98	87.96	40.00	20.00
T3	5.15	83.58	55.59	20.72	36.49	91.10	2.0 K. Gauss	
T2	6.08	89.66	60.99	23.45	22.89	94.36		
T1	10.34	100.00	60.35	27.27				
	100.00		27.27					
2-C	70.76	70.76	15.87	15.87	61.79	84.31	40.00	20.00
T3	5.11	75.87	56.48	18.61	51.96	87.46	5.0 K. Gauss	
T2	8.60	84.47	63.22	23.15	33.46	91.94		
T1	15.53	100.00	63.33	29.39				
	100.00		29.39					
3-C	68.32	68.32	14.32	14.32	67.11	83.32	40.00	20.00
T3	5.06	73.38	50.13	16.79	58.58	86.91	10.0 K. Gauss	
T2	9.14	82.51	63.23	21.93	39.16	91.69		
T1	17.49	100.00	66.62	29.74				
	100.00		29.74					
4-C	66.96	66.96	12.66	12.66	74.06	86.87	40.00	20.00
T3	5.43	72.39	52.82	15.67	65.28	90.68	15.0 K. Gauss	
T2	7.93	80.32	61.94	20.24	50.25	95.17		
T1	19.68	100.00	83.46	32.68				
	100.00		32.68					
5-C	65.55	65.55	12.24	12.24	73.07	81.94	40.00	20.00
T3	4.26	69.81	50.15	14.56	65.89	84.97	18.0 K. Gauss	
T2	9.44	79.25	60.07	19.98	46.86	90.34		
T1	20.75	100.00	67.30	29.80				
	100.00		29.80					
6-C	67.70	67.70	13.81	13.81	68.37	82.83	40.00	20.00
T3	5.20	72.90	49.74	16.37	59.61	86.55	20.0 K. Gauss	
T2	9.33	82.23	58.52	21.16	41.15	92.04		
T1	17.77	100.00	68.44	29.56				
	100.00		29.56					

Table 7. Reagent dosage effect on the separation of
Pocahontas R.O.M. coal at 90% passing 100 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifier (lb/t)	Reagent (lb/t)
1-C	58.11	58.11	13.54	13.54	73.67	71.64	10.00	5.00
T3	7.75	65.86	40.65	16.73	63.12	78.20		
T2	10.79	76.65	48.74	21.24	45.52	86.09		
T1	23.35	100.00	58.23 29.88	29.88				
2-C	55.76	55.76	11.71	11.71	77.97	69.96	20.00	10.00
T3	7.15	62.91	37.43	14.63	68.93	76.32		
T2	9.88	72.79	46.00	18.89	53.60	83.90		
T1	27.21	100.00	58.37 29.63	29.63				
3-C	50.78	50.78	9.38	9.38	83.88	65.32	40.00	20.00
T3	6.51	57.29	33.64	12.14	76.47	71.46		
T2	10.20	67.49	42.85	16.78	61.68	79.73		
T1	32.51	100.00	56.07 29.55	29.55				
4-C	55.09	55.09	10.67	10.67	79.38	68.84	60.00	30.00
T3	6.56	61.65	34.98	13.26	71.34	74.80		
T2	9.65	71.30	40.15	16.90	57.74	82.89		
T1	28.70	100.00	57.37 28.51	28.51				

Table 8. Magnetic field strength effect on the separation of
Pocahontas R.O.M. coal at 90% passing 100 mesh

	Wt. %	Cum. %	Ash%	Cum.Ash%	Cum.Ash Reject%	Cum.Coal Recovery%	Modifier (lb/t)	Reagent (lb/t)
1-C	58.87	58.87	18.22	18.22	62.88	67.70	40.00	20.00
T4	7.31	66.17	32.06	19.75	54.77	74.68	2.0 K. Gauss	
T3	6.39	72.56	37.51	21.31	46.47	80.29		
T2	14.26	86.82	49.81	25.99	21.89	90.36		
T1	13.18	100.00	47.98	28.89				
	100.00		28.89					
2-C	51.31	51.31	10.92	10.92	80.46	64.07	40.00	20.00
T4	6.08	57.39	30.68	13.01	73.95	69.98	5.0 K. Gauss	
T3	8.49	65.88	40.87	16.60	61.84	77.02		
T2	12.16	78.04	48.58	21.59	41.23	85.79		
T1	21.96	100.00	53.83	28.67				
	100.00		28.67					
3-C	46.71	46.71	8.89	8.89	85.91	60.35	40.00	20.00
T4	5.69	52.40	21.86	10.30	81.69	66.66	10.0 K. Gauss	
T3	7.36	59.76	33.20	13.12	73.40	73.63		
T2	12.76	72.52	47.07	19.09	53.03	83.20		
T1	27.48	100.00	56.89	29.48				
	100.00		29.48					
4-C	46.21	46.21	7.91	7.91	87.77	60.69	40.00	20.00
T4	5.74	51.95	22.72	9.55	83.41	67.01	15.0 K. Gauss	
T3	6.47	58.41	32.21	12.06	76.44	73.27		
T2	12.89	71.30	46.72	18.32	56.29	83.06		
T1	28.70	100.00	58.62	29.89				
	100.00		29.89					
5-C	46.08	46.08	7.54	7.54	88.19	60.35	40.00	20.00
T4	5.77	51.85	22.10	9.16	83.85	66.72	18.0 K. Gauss	
T3	6.31	58.16	30.29	11.45	77.34	72.96		
T2	11.30	69.46	44.13	16.77	60.39	81.90		
T1	30.54	100.00	58.16	29.41				
	100.00		29.41					
6-C	47.58	47.58	6.71	6.71	88.99	62.50	40.00	20.00
T4	5.05	52.62	21.68	8.15	85.21	68.07	20.0 K. Gauss	
T3	6.80	59.42	33.35	11.03	77.39	74.45		
T2	12.59	72.01	48.24	17.54	56.44	83.63		
T1	27.99	100.00	58.46	28.99				
	100.00		28.99					

Table 9. Illinois #6 -48 mesh rod mill grinding to -100,200,325,500 mesh (90% passing)
reagent enhanced wet magnetic separation at 20 kilogauss

	Wt. % C.W.Coal		BTU	Cum.BTU	Ash%	Cum.Ash%	Cum.Ash	Total Sulfur			Pyritic Sulfur			Separation
								T-S%	Cum.	Cumulat	P-S%	Cum.	Cumul.	Efficiency
	Rec.%		Rec. %				Reject%	T-S %	Reject%		P-S%	Reject%		
IL-100-MC	48.31	57.68	13070	57.92	5.40	5.40	87.44	2.29	2.29	68.03	0.69	0.69	83.97	41.90
T3	7.99	66.22	11560	66.40	15.38	6.82	81.53	3.36	2.44	60.27	1.92	0.87	76.58	42.98
T2	11.69	77.27	10805	77.98	25.12	9.96	67.39	4.04	2.72	46.62	2.81	1.20	60.82	38.80
T1	32.01	100.00	7497	100.00	43.73	20.77		5.04	3.46		3.95	2.08		
	100.00		10901		20.77			3.46			2.08			
IL-200-MC	58.97	71.13	13433	73.72	4.96	4.96	86.21	2.23	2.23	64.96	0.51	0.51	86.91	60.63
T3	4.88	75.91	9824	78.18	22.79	6.32	80.96	4.00	2.37	59.76	2.59	0.67	81.41	59.59
T2	8.84	83.03	8278	84.99	36.57	10.00	65.72	6.22	2.83	45.11	4.94	1.19	62.41	47.39
T1	27.31	100.00	5908	100.00	51.03	21.21		6.20	3.75		5.25	2.30		
	100.00		10746		21.21			3.75			2.30			
IL-325-MC	50.42	62.53	12510	62.31	3.47	3.47	92.11	1.97	1.97	73.67	0.34	0.34	92.78	55.09
T5	4.05	66.96	11662	66.97	14.89	4.32	89.39	3.27	2.07	70.16	1.83	0.45	89.66	56.63
T4	3.62	70.58	10541	70.74	22.13	5.43	85.77	4.33	2.21	66.00	3.04	0.61	85.02	55.77
T3	4.74	74.83	9396	75.14	30.24	7.30	79.31	5.68	2.47	58.87	4.30	0.89	76.45	51.59
T2	7.64	80.57	7502	80.80	41.48	11.01	65.01	6.30	2.88	46.11	5.16	1.35	59.86	40.66
T1	29.53	100.00	6581	100.00	48.80	22.17		5.89	3.77		4.81	2.37		
	100.00		10123		22.17			3.77			2.37			
IL-500-MC	52.45	65.97	13723	68.42	3.13	3.13	92.86	1.70	1.70	73.62	0.28	0.28	93.28	61.69
T5	3.27	69.30	10665	71.73	21.58	4.21	89.79	3.51	1.81	70.23	2.26	0.40	89.89	61.63
T4	3.22	72.23	5323	73.36	29.86	5.61	85.60	3.99	1.93	66.42	2.97	0.54	85.52	58.88
T3	4.16	75.79	8759	76.83	34.17	7.50	79.42	4.61	2.10	60.75	3.58	0.74	78.70	55.53
T2	6.93	80.75	7227	81.59	44.82	11.19	65.90	5.50	2.44	49.47	4.61	1.12	64.08	45.66
T1	29.97	100.00	6464	100.00	50.53	22.98		5.58	3.38		4.67	2.18		
	100.00		10520		22.98			3.38			2.18			

Table 10. Lower Kittanning -48 mesh rod mill grinding to -100,200,325,500 mesh (90% passing)
reagent enhanced wet magnetic separation at 20 kilogauss

	Wt. %	Cum.Coal Rec. %	BTU	Cum.BTU Rec. %	Ash%	Cum. Ash%	Cum.Ash Reject%	Total Sulfur			Pyritic Sulfur			Separation Efficiency
								T-S%	Cum. T-S%	Cumulative Reject%	P-S%	Cum. P-S%	Cumulative Reject%	
LK-100-MC	78.44	81.49	13963	81.63	2.29	2.29	69.78	1.16	1.16	58.93	0.37	0.37	79.29	60.93
T3	4.52	85.72	12769	85.93	12.01	2.82	60.65	3.62	1.29	51.54	2.76	0.50	70.38	56.31
T2	6.71	91.61	11772	91.82	17.39	3.91	41.01	5.81	1.63	33.95	4.97	0.83	46.60	38.43
T1	10.33	100.00	10622	100.00	23.60	5.94		7.28	2.22		6.32	1.40		
	100.00		13417		5.94			2.22			1.40			
LK-200-MC	79.28	83.44	14155	84.07	1.93	1.93	77.57	1.16	1.16	65.91	0.39	0.39	80.40	64.47
T3	4.12	87.25	12256	87.85	13.82	2.52	69.22	4.38	1.32	59.22	3.76	0.56	70.57	58.42
T2	5.75	91.99	10537	92.39	23.24	3.85	49.63	7.33	1.71	43.60	6.58	0.94	46.59	38.98
T1	10.85	100.00	9362	100.00	31.20	6.82		7.50	2.34		6.77	1.58		
	100.00		13349		6.82			2.34			1.58			
LK-325-MC	80.05	84.19	13954	84.93	1.92	1.92	77.22	1.12	1.12	62.70	0.41	0.41	80.85	65.77
T3	3.67	87.46	11203	88.05	17.03	2.58	67.96	5.67	1.32	54.05	5.00	0.61	70.13	58.18
T2	4.91	91.61	10274	91.89	21.08	3.61	52.61	7.45	1.66	38.83	6.80	0.95	50.64	42.53
T1	11.37	100.00	9383	100.00	31.22	6.75		8.21	2.40		7.63	1.71		
	100.00		13152		6.75			2.40			1.71			
LK-500-MC	80.26	84.69	14306	85.03	1.56	1.56	81.33	1.02	1.02	63.97	0.48	0.48	78.07	63.10
T3	3.19	87.56	11489	87.74	16.06	2.11	73.69	5.23	1.18	56.63	4.76	0.64	69.43	57.17
T2	4.09	90.83	10613	90.96	25.42	3.20	58.18	6.45	1.43	45.02	6.02	0.89	55.41	46.36
T1	12.46	100.00	9801	100.00	31.31	6.71		8.21	2.27		7.81	1.76		
	100.00		13504		6.71			2.27			1.76			

Table 11. Pocahontas -48 mesh rod mill grinding to -100,200,325,500 mesh (90% passing)
reagent enhanced wet magnetic separation at 20 kilogauss

		Total Sulfur					Pyritic Sulfur							
	Wt. %	Cum.Coal	BTU	Cum.BTU	Ash%	Cum.	Cum.Ash	T-S%	Cum.%	Cumulati	P-S%	Cum.%	Cumul.	Separation
	Rec.%			Rec. %	Ash%	Reject%			Reject%		P-S%	Reject%	Efficiency	
Poc-500-M	33.07	47.67	14708	47.33	2.57	2.57	97.38	0.69	0.69	67.24	0.08	0.08	93.51	40.84
T5	3.10	51.11	11288	50.73	24.88	4.48	95.00	0.70	0.69	64.13	0.33	0.10	91.00	41.73
T4	2.97	54.10	18183	53.65	31.86	6.56	92.08	0.76	0.70	60.89	0.45	0.13	87.72	41.37
T3	3.81	57.60	9421	57.15	37.93	9.34	87.62	0.61	0.69	57.55	0.50	0.16	83.04	40.19
T2	7.72	63.78	8001	63.16	45.90	14.91	76.68	0.72	0.69	49.57	0.55	0.22	72.63	35.78
T1	49.33	100.00	7675	100.00	50.37	32.40		0.70	0.70		0.60	0.41		
	100.00		10517		32.40			0.70			0.41			
Poc-325-M	38.01	54.30	15921	57.84	2.58	2.58	96.92	0.69	0.69	63.61	0.07	0.07	93.39	51.24
T5	2.76	57.30	11200	60.80	25.73	4.15	94.68	0.73	0.69	60.81	0.30	0.09	91.34	52.13
T4	3.12	60.55	10676	63.98	29.05	5.92	91.83	0.78	0.70	57.43	0.36	0.11	88.55	52.53
T3	4.36	64.74	10273	68.26	34.49	8.50	87.10	0.71	0.70	53.14	0.48	0.14	83.35	51.61
T2	8.58	71.72	7996	74.82	44.52	13.94	75.09	0.74	0.71	44.33	0.49	0.19	72.91	47.73
T1	43.17	100.00	6102	100.00	55.32	31.80		0.74	0.72		0.68	0.40		
	100.00		10462		31.80			0.72			0.40			
Poc-200-M	39.59	54.94	14771	57.41	4.27	4.27	94.55	0.64	0.64	64.39	0.07	0.07	90.82	48.23
T5	3.16	58.36	11228	60.89	25.36	5.83	91.97	0.75	0.65	61.06	0.30	0.09	87.67	48.57
T4	3.87	62.34	10588	64.92	29.07	7.76	88.34	0.71	0.65	57.20	0.29	0.10	83.96	48.87
T3	4.69	66.81	9643	69.35	34.27	10.18	83.16	0.71	0.66	52.52	0.36	0.13	78.36	47.72
T2	9.17	73.96	7751	76.33	46.22	15.65	69.49	0.80	0.68	42.21	0.51	0.19	62.86	39.20
T1	39.52	100.00	6100	100.00	54.54	31.02		0.76	0.71		0.48	0.30		
	100.00		10186		31.02			0.71			0.30			
Poc-100-M	32.43	44.61	14476	41.60	4.74	4.74	95.00	0.68	0.68	70.90	0.07	0.07	92.42	34.02
T5	4.31	50.00	13266	46.90	13.40	5.76	93.12	0.74	0.69	66.70	0.19	0.08	89.68	36.58
T4	6.25	57.58	12821	54.55	15.93	7.24	89.88	0.74	0.69	60.59	0.18	0.10	85.93	40.47
T3	6.56	64.64	11232	61.98	25.50	9.65	84.44	0.75	0.70	54.10	0.27	0.12	80.01	41.99
T2	12.17	75.31	8924	74.39	39.28	15.50	68.89	0.79	0.72	41.42	0.49	0.19	60.09	34.48
T1	38.28	100.00	5872	100.00	55.33	30.74		0.82	0.76		0.47	0.30		
	100.00		10138					0.76			0.30			

END

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