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BENEFICIATION OF A HIGH-SULPHUR THERMAL COAL FROM THE MINTO AREA, NEW BRUNSWICK

by

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ABSTRACT

A 3-ton sample of coal from Minto, N.B. containing 6.7% sulphur and 19% ash was washed in the CANMET Process pilot plant at the Western Research Laboratory in Edmonton. Objective of the test was to ascertain the degree of sulphur reduction possible at a yield of approx 75%.

A cutpoint in the range 1.6-1.8 sp gr gave a clean coal having a sulphur content of 4.8% and an ash content of 10.3% at a yield of 74.6%. This result was in close agreement with values predicted from performance evaluation calculations based on the washability data.

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INTRODUCTION

The current rise in energy costs has fostered a renewed interest in coal as a primary source of energy. For at least the next few decades, the exploitation of coal resources will be faced with having to meet new and sometimes difficult economic and environmental realities. Efficient cleaning is not only desirable, but is a necessity to effect reduced handling, utilization and transportation costs. Sulphur removal is necessary from the point of view of environmentally hazardous emissions.

The high sulphur content of coals from the Minto Area of New Brunswick constitutes a serious drawback to their use for power generation. A request was received from the government of New Brunswick through Mr. T.E. Tibbetts of the Energy Research Laboratories in Ottawa to determine the extent of sulphur removal that could be achieved by washing in the CANMET Process pilot plant located at the Western Research Laboratory (WRL) in Edmonton. This objective falls within the scope of the Energy Research Program (ERP) whose aims include the development of improved cleaning processes for fine coal to ensure the availability of sufficient quantities of washed coal at reasonable cost for consumption in the metallurgical and steam-generation industries, both domestically and for export.

Sulphur in coal occurs in organic, sulphate and pyritic forms. Organic sulphur is considered as being an integral part of the coal molecule and is not removable by physical means of separation. Sulphate sulphur is normally a water-soluble oxidation product and can be readily removed during the washing process. Pyritic sulphur occurs as discrete particles, often microscopic in size, and can often be significantly reduced in quantity by using a combination of size reduction by grinding to liberate the particles and gravimetric separation.

In the CANMET Process, coal is cleaned in bulk using compound water (automedium) cyclones at cutpoints that may range from less than 1.3 to as high as 2.5 specific gravity. Process water is recovered internally and recirculated within the plant and products are dewatered in centrifuges. Reject (coarse and fine) is discharged in a form that can be readily handled for disposal.

A 3-ton sample of Minto coal was received at WRL on March 11, 1977 for feasibility washing tests. No surface moisture was visible and the coal was judged to be hard because of the small amount of fines present. The objective of the tests was to determine the reduction in sulphur and ash attainable at approx 75% weight recovery of clean product. The sample was crushed to minus 3/8 in. and a small split sample was taken for size and washability analyses. The remaining coal was washed in the pilot plant on March 31, 1977 to give a clean coal and two reject (coarse and fine) products.

WASHABILITY CHARACTERISTICS

The size consist of the crushed coal is given in Table 1 and washability analyses on the 3/8-in. x 28 mesh and 28 x 150 mesh size fractions are presented in Tables 2 and 3 with respective washability curves for ash and sulphur in Figures 1 to 4.

It is evident from the data and washability curves that ash reduction can easily be achieved and that a cutpoint between 1.6 and 2.0 sp gr would produce an acceptable thermal coal containing approx 11% ash. In this cutpoint range, little would be accomplished for sulphur, however, and the clean product would have a content of approx 5%. Sulphur could be reduced to 3.9% at cutpoints between 1.35 and 1.50 sp gr but at a recovery of only 55% which may be unacceptably low from an economic standpoint.

It is seen from the washability data in Tables 2 and 3 that there is little difference in sulphur distribution between the two size fractions and it can be concluded that little or no liberation of pyritic sulphur took place during crushing. This could indicate either the presence of very high organic sulphur content or that the pyritic sulphur is very finely intergrown. It was found that the combined organic and sulphate sulphur content for Minto coal averaged 2.4% in analyses reported earlier (1), with a standard deviation of 0.33%. An extremely fine liberation size of 1-2 microns for the pyritic sulphur has been reported (2) and much more grinding would be required for complete liberation. The overall sulphur content drops slightly as particle size decreases as shown in Table 1.

Performance Evaluation

Before processing the sample, calculations were made to predict the yields and ash and sulphur contents of the products that could be expected for a range ofcutpoints (dp) and washing efficiencies. The efficiency (or sharpness) of separation is expressed by the probable error (r) which states the accuracy with which a given washing process can separate a raw coal into clean and reject products. It is generally accepted that the probable error is essentially independent of the coal being washed and that it therefore represents a measure of the accuracy of the washing unit itself. The range of r used in the calculations (0.08 to 0.12 for 3/8 in. x 28 mesh and 0.14 to 0.20 for 28 x 150 mesh) was determined from previous experience with coals of similar size. The performance evaluation (PE) curves showing expected results are presented in Figures 5 and 6 for the 3/8 in. x 28 mesh and 28 x 150 mesh fractions respectively.

An example of how to read this type of graph is given in Figure 5. When the plant is adjusted to produce a yield of 70% at a cutpoint d_p = 1.57 and a probable error, r = 0.10, an actual ash content of 9% can be expected for the clean coal with a corresponding 41% ash for the reject. This compares to theoretical ash contents of 7.7 and 44% respectively at the same yield. Expected sulphur contents are 4.65% for the clean coal and 12% for the reject.

TEST PROCEDURE AND DISCUSSION OF RESULTS

The raw coal was crushed to minus 3/8 in. and stored in the feed bin of the CANMET Process pilot plant (see flowsheet in Figure 7) prior to testing. During the test run, incremental samples were collected from the end products and analyzed for ash, total sulphur and moisture. The results of analysis are given below. Sulphur values were determined using a Leco analyzer which is not a standard ASTM method. Results are relative and therefore may vary slightly from the actual values. The difference in total sulphur of the raw feed (6.7%) and the value for the reconstituted feed may be partly due to dissolved sulphates.

	Clean Coal	Reject Coarse	Reject Fine	Feed (Reconst'd)
Yield, %	74.5	16.7	8.8	100.0
Ash, %	10.3	46.6	29.0	18.0
Sulphur, %	4.8	11.2	6.4	6.0
Moisture, %	5.2	24.9	10.8	-

Cyclone settings during operation were as follows:

Cyclone Settings	Main Cleaning Circuit			Slimes Circuit		
	AM I	AM II	Cl.C	AM I	AM II	Cl. C
V.F.* Clearance, in.	1.6	2	-	7	3	-
Pressure, psi	24	7	12	21	10	8
Cone Type	L	M	-	L	M	-
Spacer, in.	-	-	-	4	-	-

Ash and sulphur contents obtained in the test agree closely with the predicted values of the performance evaluation curves. The results also show that a cutpoint above 1.6 sp gr would give high recovery at high organic efficiency**. Generally speaking, considering its simplicity and low operating cost, performance of the compound water cyclone (r - 0.08) compares favourably with the heavy-medium cyclone at cutpoints between 1.6 and 1.8 sp gr.

Agglomeration work carried out by Capes et al (2) on Minto coal ground to 100% minus 50 microns, 70% minus 22 microns, showed that in the best cases, total sulphur content was reduced from 6.6% to the range of 4-5% when using Varsol added at the rate of 20 to 40% by weight of solids. These results are in agreement with previous froth flotation work where it was found that rejection of more than 50% of the pyrites was difficult. Bearing

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* Vortex Finder

** Organic Efficiency = (Yield of washed coal x 100)/(Theoretical yield of washed coal at the same ash content)

in mind these results and the comparable sulphur reduction achieved in the present test by washing the coal in a relatively coarse state using compound water cyclones, there is little reason to believe that more elaborate (and more expensive) treatment would produce significantly better results.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the sample received, results of the pilot plant showed that Minto coal can be effectively cleaned using the CANMET Process to reduce ash content from 18% to 10.3% with accompanying reduction in sulphur content from 6.7% to 4.8% at 74.6% recovery. No conclusive evidence was obtained from analysis of the two size fractions that size reduction by grinding would liberate intergrown pyritic sulphur. Results of oil agglomeration tests reported elsewhere (2) indicate that the liberation size of the pyrites is in the order of 1 to 2 microns.

Further studies are recommended to ascertain the liberation size and the amount of organic sulphur present.

REFERENCES

1. Nicolls, J.H.H. "Analysis of Canadian Coals and Peat Fuels"; Mines Branch, Dept. of Mines and Technical Surveys; Report No. 831, pp 84-104; 1952.

2. Capes, C.E., McIlhinney, A.E., Sirianni, A.F. and Puddington, I.E. "Bacterial Oxidation in Upgrading Pyritic Coals"; Coal Processing; MSS Information Corp., New York; pp 10-19; 1976.

TABLE 1

Size Consist and Analysis of Crushed Minto Coal
(3/8-in x 0)

Size Fraction	Wt %	Ash %	Sulphur %
3/8-in x 28 M	80.77	18.58	6.97
28 x 150	11.74	20.30	5.92
- 150	7.49	32.17	4.84
Total	100.00	19.80	6.69

TABLE 2 :WASHING CHARACTERISTICS OF MINTO COAL 3/8-in. x 28 MESH

SPECIFIC GRAVITY FRACTIONS	ELEMENTARY DATA PERCENT WEIGHT	ASH	SULPHUR	CUMULATIVE DATA, PERCENT FLOAT WEIGHT	ASH	SULPHUR	SINK WEIGHT	ASH	SULPHUR
FLOAT1.30	24.69	3.07	2.76	24.69	3.07	2.76	100.00	18.58	6.97
1.30-1.35	18.26	6.37	4.28	42.95	4.47	3.41	75.31	23.67	8.35
1.35-1.40	12.31	10.00	5.59	55.26	5.70	3.89	57.05	29.20	9.65
1.40-1.45	8.52	13.70	6.52	63.78	6.77	4.24	44.74	34.49	10.76
1.45-1.50	6.24	17.55	7.12	70.02	7.73	4.50	36.22	39.38	11.76
1.50-1.60	8.34	22.81	7.70	78.36	9.34	4.84	29.98	43.92	12.73
1.60-1.80	7.52	32.21	9.30	85.88	11.34	5.23	21.64	52.05	14.66
1.80-2.00	3.09	42.42	12.21	88.97	12.42	5.47	14.12	62.62	17.52
2.00-SINK	11.03	68.28	19.01	100.00	18.58	6.97	11.03	68.28	19.01

TABLE 3 :WASHING CHARACTERISTICS OF MINTO COAL 28 x 150 MESH

SPECIFIC GRAVITY FRACTIONS	ELEMENTARY DATA PERCENT WEIGHT	ASH	SULPHUR	CUMULATIVE DATA, PERCENT FLOAT WEIGHT	ASH	SULPHUR	SINK WEIGHT	ASH	SULPHUR
FLOAT1.30	34.84	2.13	2.39	34.84	2.13	2.39	100.00	20.30	5.92
1.30-1.35	14.05	6.31	4.18	48.89	3.33	2.90	65.16	30.02	7.80
1.35-1.40	9.43	9.84	5.26	58.32	4.38	3.29	51.11	36.54	8.80
1.40-1.45	5.68	13.92	6.07	64.00	5.23	3.53	41.68	42.58	9.60
1.45-1.50	4.81	16.69	6.31	68.81	6.03	3.73	36.00	47.10	10.16
1.50-1.60	6.73	22.17	7.49	75.54	7.47	4.06	31.19	51.79	10.75
1.60-1.80	6.45	31.46	9.08	81.99	9.36	4.46	24.46	59.94	11.65
1.80-2.00	2.89	43.07	11.13	84.88	10.50	4.68	18.01	70.14	12.57
2.00-SINK	15.12	75.32	12.84	100.00	20.30	5.92	15.12	75.32	12.84

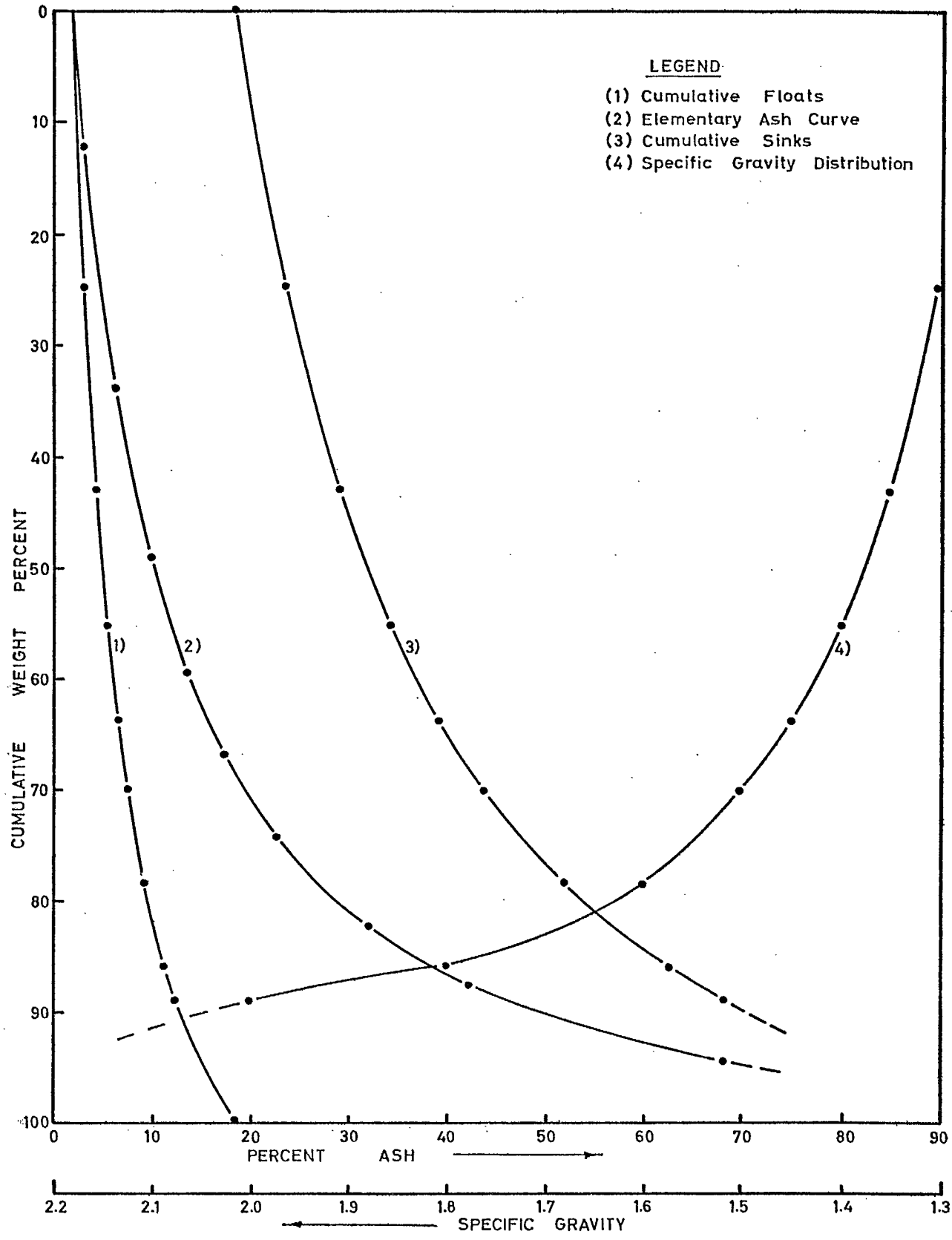

Figure 1 - Ash Washability Curves for 3/8-in.x 28 Mesh Minto Coal.

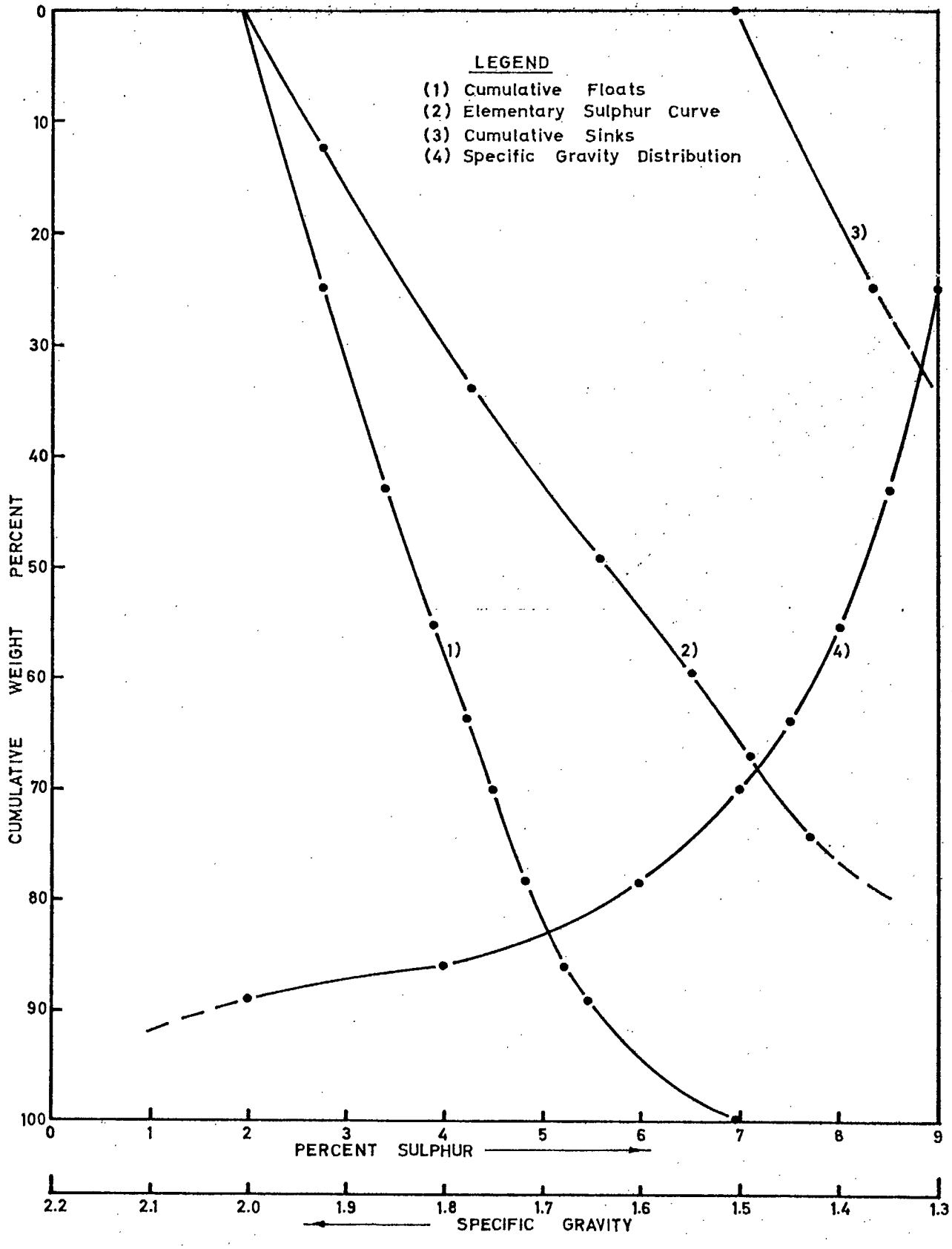

Figure 2 - Sulphur Washability Curves for 3/8-in. x 28 Mesh Minto Coal.

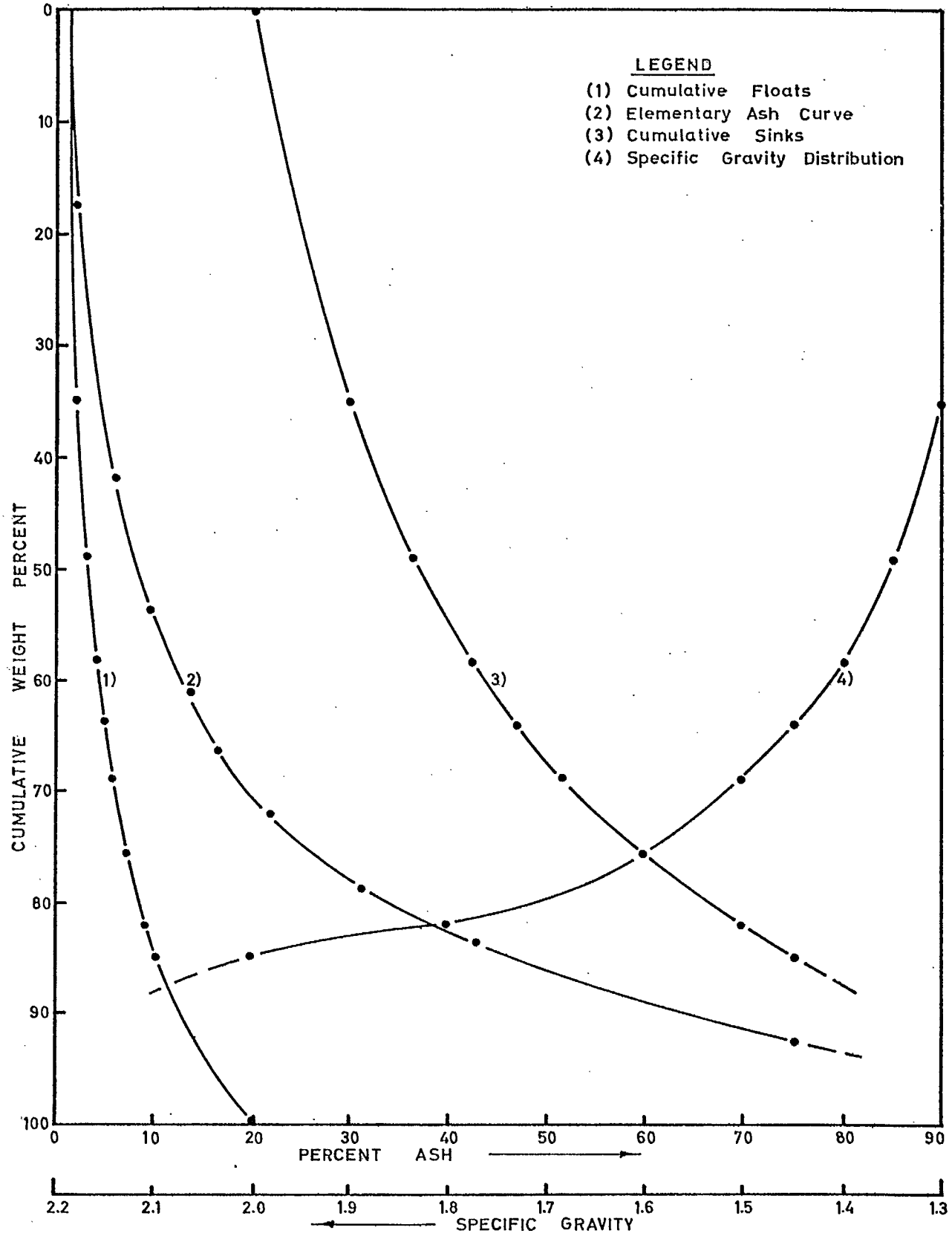

Figure 3 - Ash Washability Curves for 28 x 150 Mesh Minto Coal.

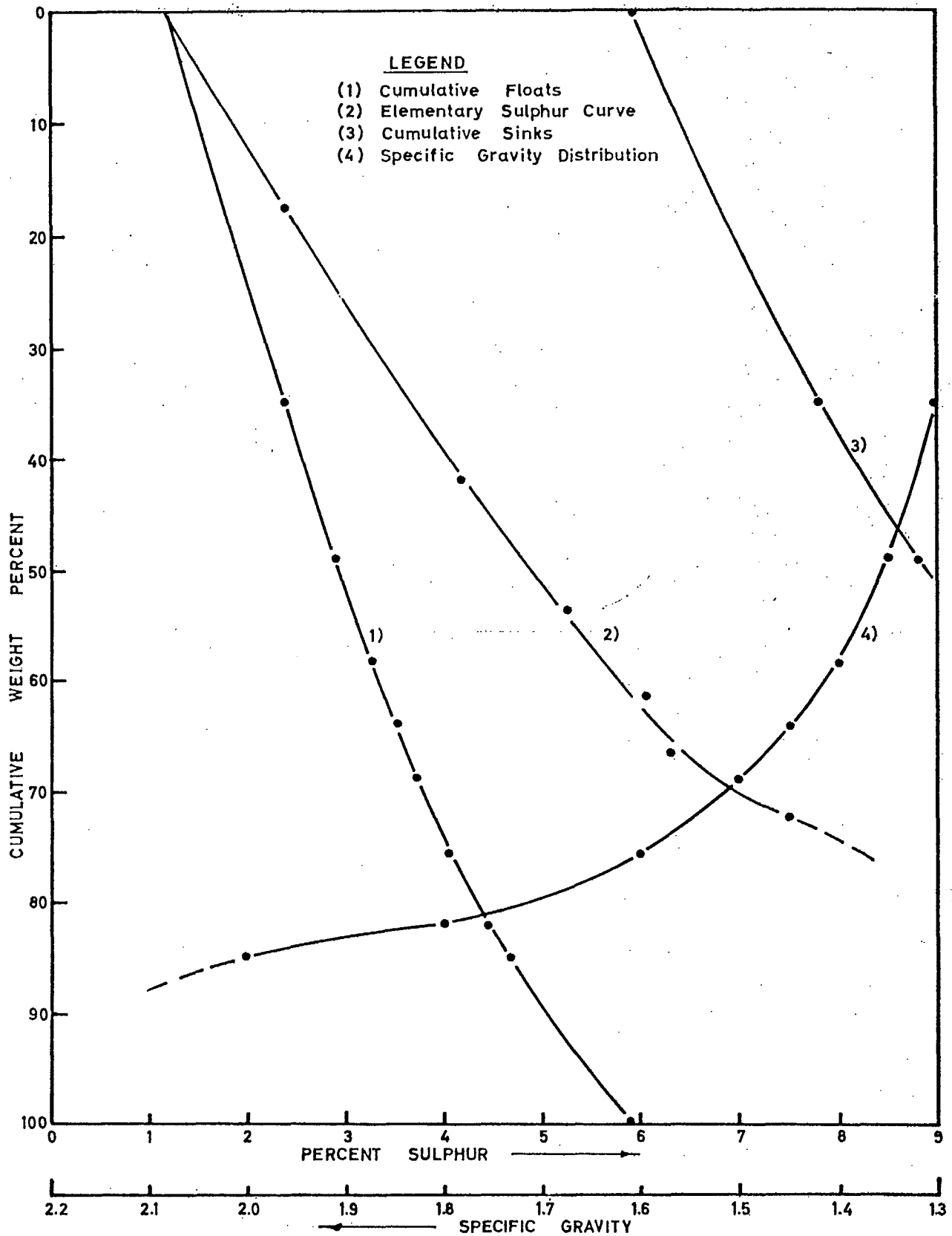

Figure 4 - Sulphur Washability Curves for 28 x 150 Mesh Minto Coal.

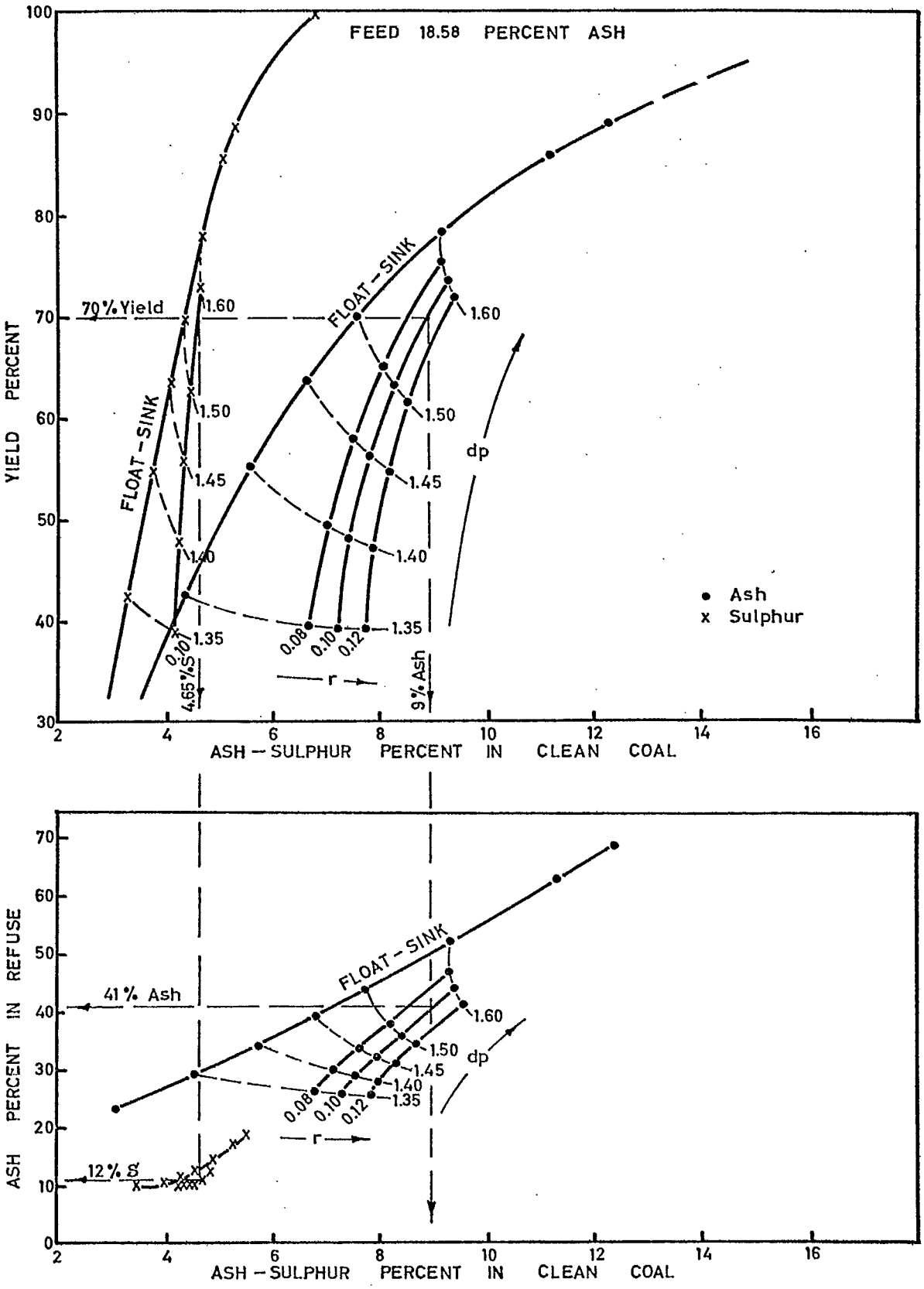

Figure 5 - Performance Evaluation Curves for 3/8 in. x 28 Mesh Minto Coal.

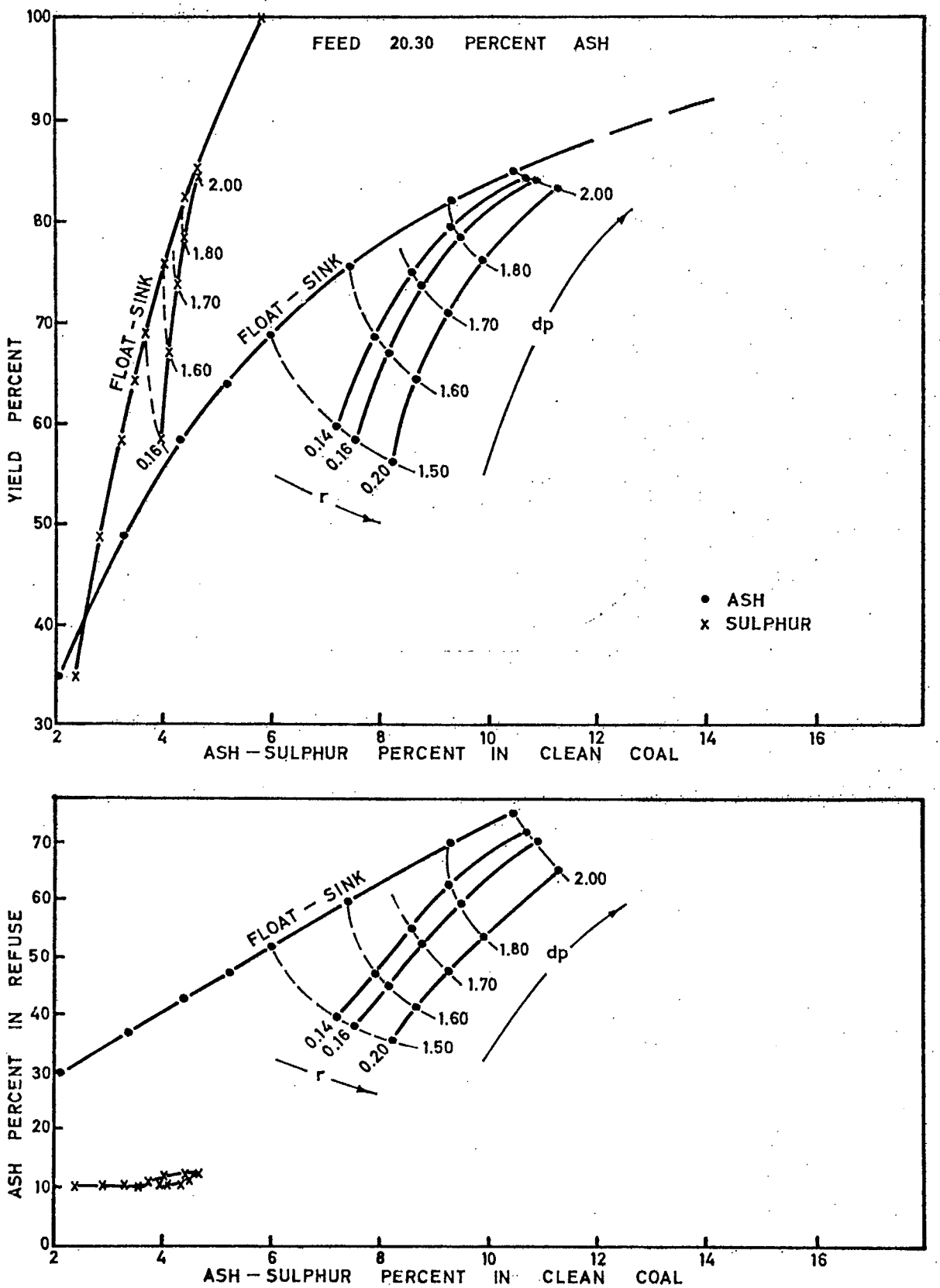

Figure 6 - Performance Evaluation Curves for 28 x 150 Mesh Minto Coal.

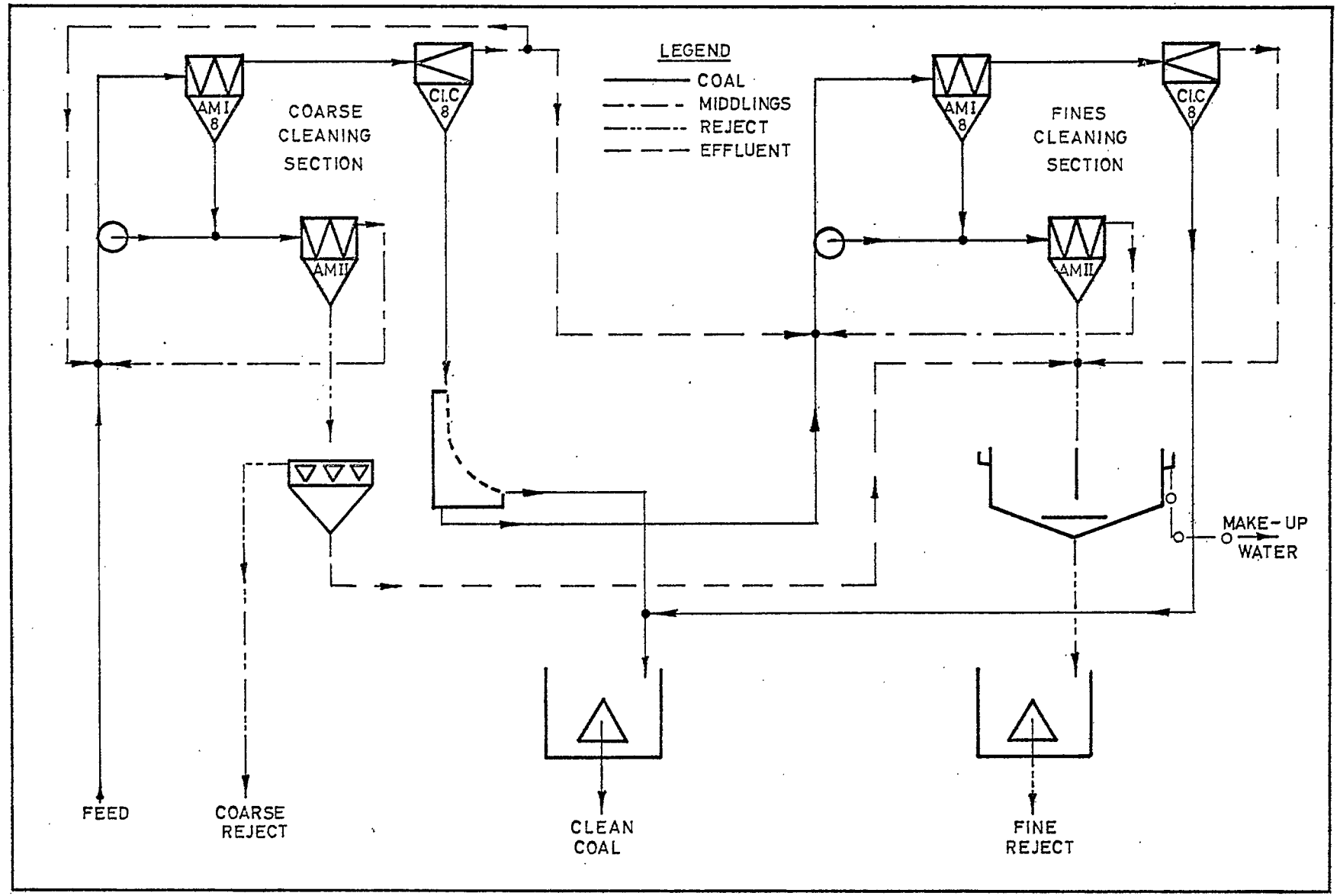

Figure 7 - Simplified Flowsheet: CANMET Process Pilot Plant.