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FEASIBILITY STUDY ON RECOVERY OF COAL FROM FINE REFUSE - KAISER RESOURCES

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FEASIBILITY STUDY ON RECOVERY OF COAL FROM FINE REFUSE - KAISER RESOURCES

by

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SUMMARY

An 80 lb sample of fine refuse from Lagoon C - Kaiser Resources was received at the Western Research Laboratory (WRL) on April 15, 1977 to investigate means and feasibility of recovering saleable coal.

Washability characteristics were determined on two size fractions (plus 28 mesh and 28 x 150 mesh), bench and pilot plant investigations were carried out using Compound Water Cyclones, froth flotation and oil agglomeration.

A flowsheet is proposed which includes desliming at 48 mesh, scalping by Compound Water Cyclone, crushing and froth flotation for production of a 10-15% ash coal. A 5-10 ton sample of lagoon C material would be required for pilot plant tests to confirm the flowsheet.

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INTRODUCTION

The accumulation of pond solids of relatively low ash content is a common problem of new washeries in western Canada, especially in the first few years of operation. Start-up problems coupled with the presence of large amounts of fines resulting from degradation of friable coal cause some loss of fine low-ash coal to the fine reject. The losses most often occur in froth flotation and can result from one or more of the following factors:

1) the presence of oxidized coal
2) the presence of coal particles coarser than 28 mesh
3) overloading of the flotation cells due to excessive fines (friable coal) or build-up of slimes in the flotation circuit.

Reject fines are generally difficult to clean because of intergrown coal particles, small average particle size and sometimes large amounts of minus 200-mesh slimes. High coal prices and environmental considerations may justify elaborate methods to clean such materials provided that the value of recovered coal can cover the cost of reclamation (ponds) and of clearing needed space around washeries.

A small sample (80 lb) of approximately minus 14 mesh refuse from lagoon C of Kaiser Resources Ltd. was received on April 15, 1977. Objective was to look into the feasibility of developing a viable process for recovering a marketable product from this material and to reclaim the pond area.

WASHABILITY CHARACTERISTICS

The screen assay in Table 1 shows that the fractions finer than minus 48 mesh have a relatively high ash content. Material in the 48 x 150 mesh range (23.5% by weight of total) is highest in ash indicating that during washing in the plant, the optimum sizes for froth flotation (48-150 mesh) were cleaned relatively efficiently.

Washability data analysis for the plus 28 and 28 x 150 mesh fractions in Tables 2 and 3 indicate the presence of considerable amounts of middlings (unliberated coal particles) in the range of 1.5 to 2.0 specific gravity. These middlings amount to 39% of the plus 28 mesh fraction and 37% of the 28-150 mesh fraction. Washability data and curves for the plus 150 mesh fraction (87.5% of the total sample) are given in Table 4 and Figure 1 respectively. By way of example, the dashed lines in Figure 1 represent a separation at 2.0 sp gr (curve 4) whereby 74.6% of the material can theoretically be recovered at 25% ash (curve 1) yielding a reject containing 76% ash (curve 3). The point of intersection on curve 2 indicates that the separation would entail the removal of all material > 59% ash to the reject.

The performance evaluation (PE) represented by the network of curves in Figure 2, indicates actual ash contents and yields that may be expected for the plus 150 mesh fraction when cleaning the lagoon material at cut-points ranging between 1.5 to 2.0 sp gr for probable errors of 0.16 to 0.25. The dashed line in Figure 2 shows the expected result for a 12-in. diameter Compound Water Cyclone, (probable error = 0.20) at a cutpoint of 2.0 sp gr. The yield error would be 6% at a clean product ash content of 25.7%; the corresponding ash content in the reject would be 67%. This result suggests that Compound Water Cyclones would be adequate for scalping but that a second cleaning stage such as froth flotation would be necessary to produce a low ash coal.

PILOT PLANT TESTS

Froth Flotation

Tests on dry-screened 28 mesh x 0 material were carried out in a standard 1000-g Denver Laboratory Flotation machine. Results are summarized in Table 5. The high ash of froth could have resulted from the following factors;

(1) Presence of oxidized coal or middlings particles;

(2) Interference of minus 150 mesh slimes in the froth.

Two-stage Compound Water Cyclones

A 30-lb split sample of the sludge was tested in a two-stage 4-in. diameter Compound Water Cyclone (CWC) circuit (Figure 3). The primary cyclone (I) had an L-type cone and was fitted with an extended body, allowing a 3 1/2 in. vortex finder clearance (VFC); the secondary cyclone (II) had an M-cone. Removal of high ash slimes from the over-product of the primary cyclone was effected using a standard 4-in. diameter thickener cyclone. Results of the test shown in Figure 3 indicate a 25% ash clean coal at low yield (38.5%). The size of sample was not sufficient to allow further testing for optimizing cyclone operating variables such as VFC, and % solids in the feed to achieve results comparable to those predicted (Figure 2). The 25% ash clean coal was ground to minus 48 mesh to create fresh unoxidized surfaces and liberate coal particles from the middlings for use in a bench froth flotation test. The preliminary test on a small sample produced a froth containing 16% ash. Further test work is needed to study the combined effect of scalping by water-only cyclones and cleaning of the crushed high ash product of the water-only cyclone by froth flotation.

Oil Agglomeration

Tests were carried out on minus 28 mesh material pulped to 50% solids, using dieseline oil additive (1-10% by weight of the coal). Only limited agglomeration was observed, even at levels of 7-10% oil. A second split sample was pulverized to minus 60 mesh, pulped to 10% solids, conditioned with 7% by weight dieseline oil for 5 minutes, then dewatered over a 48 mesh vibrating screen. The best result obtained was 28% recovery of an agglomerate containing 22% ash. Earlier work at WRL (1) indicated that longer conditioning was required to effect agglomeration of high ash coal and large amounts of oil were required to give low ash coal. Agglomeration of froth from a flotation test similar to the one mentioned earlier was achieved at 1-2% oil addition. The presence of a great excess of high ash particles in the pond material may explain the difficulty of effecting agglomeration since this requires bringing the low ash coal particles together. It appears that scalping for prior removal of the bulk of the high ash material either by CWC's or by froth flotation would be beneficial to the oil agglomeration process and would also be the more economical approach in view of lower capacity requirements that would result for this process.

DISCUSSION OF RESULTS

Results of the washability analyses and tests carried out on the 80 lb sample of lagoon material indicate the following:

(1) No single process appears capable of recovering low ash metallurgical grade coal;

(2) The presence of large amounts of middlings (44.3% of total plus 150 mesh) necessitates further crushing to liberate the coal particles;

(3) Desliming before cleaning is advantageous for removal of high ash slimes (the minus 48 mesh material contains 51% ash).

Energy requirements constitute an important factor in determining the methods of beneficiation that can be used. In the case of oil agglomeration, for example, the horse power required for pulverizing can be calculated as follows (2):

$$P/T = 1.46\ W_i\ (1/\sqrt{D_p} - 1/\sqrt{D_f})$$

where, P = the power required, hp

T = rate of processing, tons per minute

D_f = size of mesh passing 80% of the raw feed, ft

D_p = size of mesh passing 80% of the product, ft

W_i = work index, hp-min/ton.

As applicable to the present case, a work index of 14 was taken as the horse power-min that would be required to reduce one ton of the pond material represented by the sample from 35 mesh to 80% passing 10 microns. The 10-micron size was determined by the National Research Council as being the optimum size for oil agglomeration of this lagoon material.* According to the above equation the hp/hour needed to pulverize 100 tph of coal from 35 mesh to 10 microns would be 5027. This is

* Reported by Mr. C.J. Palmer, Kaiser Resources

about 1.3 times the hp required to operate a complete washery of 750 tph capacity. Considering in addition, the cost for about 10% by weight of fuel oil, the total operating cost could be prohibitive. Under these circumstances, oil agglomeration should therefore be considered only as a last resort where other, cheaper, methods would not be capable of achieving the required ash reduction.

On the basis of the washability characteristics and of bench and pilot plant test results, the flowsheet in Figure 4 is recommended for further investigation and verification by pilot plant testing. The flowsheet incorporates the following:

1. Desliming on a 48 mesh screen to remove high ash slimes.
2. Cleaning Section:
   a) CW Cyclone: plus 48 mesh material is washed in 12-in. CW cyclone then thickened in a 12-in. classifier cyclone. The product is expected to contain 20-25% ash and could be used as a thermal coal.

   b) Froth flotation: for further cleaning, the underflow of the classifier cyclone is crushed to minus 48 mesh to liberate coal from the middling particles and to create fresh unoxidized surfaces. Projected quality of the clean coal is in the range of 10-15% ash depending on the feed material to the system.
3. Water Recovery: slimes from the desliming screen and the flotation tailings are flocculated and fed to a thickener.
4. Drying: clean coal products are dewatered either with a high-speed centrifuge or with a filter.

CONCLUSIONS

On the basis of the sample received, the following is concluded:

1. Relatively efficient cleaning of the minus 48 mesh coal fraction appears to have occurred in the Kaiser washery froth flotation cells and there was therefore little coal found in that fraction to be recovered. A desliming step would be required to remove high ash

slimes before cleaning.

2. Washability characteristics of the pond refuse and the bench and pilot plant tests showed that crushing is needed to liberate intergrown coal particles and to produce fresh surfaces for froth flotation and/or oil agglomeration.
3. Results of preliminary oil agglomeration tests showed no significant improvement in product quality over CW Cyclone or froth flotation product.
4. A flowsheet which includes desliming, scalping in Compound Water Cyclones, followed by crushing and froth flotation such as proposed could be expected to produce coal containing 10-15% ash. It is recommended that further investigation based on this flowsheet be carried out on a 5-10 ton sample of the lagoon material.

REFERENCES

1. Mikhail, M.W., "Cleaning of flotation tailings at Cardinal River Coal Company"; CANMET, Laboratory report MREC 74/75 WRL; May 1974.
2. Zanker, A., "Estimating power for crushing and grinding"; Chemical Engineering; p. 105; April 14, 1975.

TABLE 1

Size Consist of Lagoon C Tailings - Kaiser Resources

Size Fraction Mesh	wt %	Ash %	Cumulative wt %	Cumulative Ash %
14	6.48	21.60	6.48	21.60
14 x 28	29.11	27.37	35.59	26.32
28 x 48	28.39	39.17	63.98	32.02
48 x 100	17.90	52.53	81.88	36.51
100 x 150	5.60	52.39	87.48	37.52
150 x 200	4.28	48.54	91.76	38.04
-200	8.24	47.88	100.00	38.85
Total	100.00	38.85	-	-

TABLE 2: Washing Characteristics of Kaiser Resources - Lagoon C (Plus 28 Mesh) *35.59%

Specific Gravity Fractions	Elementary Data Percent		Cumulative Data, Percent Float		Sink	
	Weight	Ash	Weight	Ash	Weight	Ash
Float1.30	2.74	2.35	2.74	2.35	100.00	26.99
1.30-1.35	7.63	6.21	10.37	5.19	97.26	27.68
1.35-1.40	14.79	10.19	25.16	8.13	89.63	29.51
1.40-1.45	18.33	14.94	43.49	11.00	74.84	33.33
1.45-1.50	9.09	20.09	52.58	12.57	56.51	39.29
1.50-1.60	15.05	26.31	67.63	15.63	47.42	42.97
1.60-1.80	15.81	38.10	83.44	19.89	32.37	50.72
1.80-2.00	8.44	53.53	91.88	22.98	16.56	62.76
2.00-Sink	8.12	72.36	100.00	26.99	8.12	72.36

TABLE 3: Washing Characteristics of Kaiser Resources - Lagoon C (28 x 150 Mesh) **51.89%

Specific Gravity Fractions	Elementary Data Percent		Cumulative Data, Percent Float		Sink	
	Weight	Ash	Weight	Ash	Weight	Ash
Float1.30	2.92	1.86	2.92	1.86	100.00	45.50
1.30-1.35	4.25	5.30	7.17	3.90	97.08	46.82
1.35-1.45	6.37	8.71	13.54	6.16	92.83	48.72
1.40-1.45	7.97	13.23	21.51	8.78	86.46	51.66
1.45-1.50	4.69	17.99	26.20	10.43	78.49	55.57
1.50-1.60	9.20	25.03	35.40	14.22	73.80	57.95
1.60-1.80	15.04	37.21	50.44	21.08	64.60	62.64
1.80-2.00	12.66	51.83	63.10	27.25	49.56	70.36
2.00-Sink	36.90	76.72	100.00	45.50	36.90	76.72

TABLE 4: Washing Characteristics of Kaiser Resources - Lagoon C Plus/28 Mesh

Specific Gravity Fractions	Elementary Data Percent		Cumulative Data, Percent Float		Cumulative Data, Percent Sink	
	Weight	Ash	Weight	Ash	Weight	Ash
Float1.30	2.85	2.05	2.85	2.05	100.00	37.97
1.30-1.35	5.63	5.80	8.48	4.54	97.15	39.02
1.35-1.40	9.80	9.62	18.28	7.26	91.52	41.06
1.40-1.45	12.18	14.28	30.46	10.07	81.72	44.83
1.45-1.50	6.48	19.19	36.94	11.67	69.54	50.19
1.50-1.60	11.58	25.71	48.52	15.02	63.06	53.37
1.60-1.80	15.35	37.58	63.87	20.44	51.48	59.59
1.80-2.00	10.94	52.36	74.81	25.11	36.13	68.95
2.00-Sink	25.19	76.15	100.00	37.97	25.19	76.15

Table 5-Froth Flotation Tests on
Lagoon C Tailings (28 Mesh x 0) - Kaiser Resources

PRODUCT	FLOTATION TIME (SECONDS)	WT%		ASH%	
		TEST I*	TEST II**	TEST I	TEST II
FROTH A	30	59.78	22.24	36.16	25.42
B	90	5.31	7.69	34.15	38.69
C	180	3.23	6.69	44.40	48.15
TAILINGS		31.68	63.38	67.23	54.21
TOTAL	-	100.00	100.00	46.16	46.21

REMARKS: Feed solids content 10% by wt.
Reagents: 1 part MIBc + 2 parts kerosene
* 0.5 lb/Ton, ** 0.2 lb/Ton

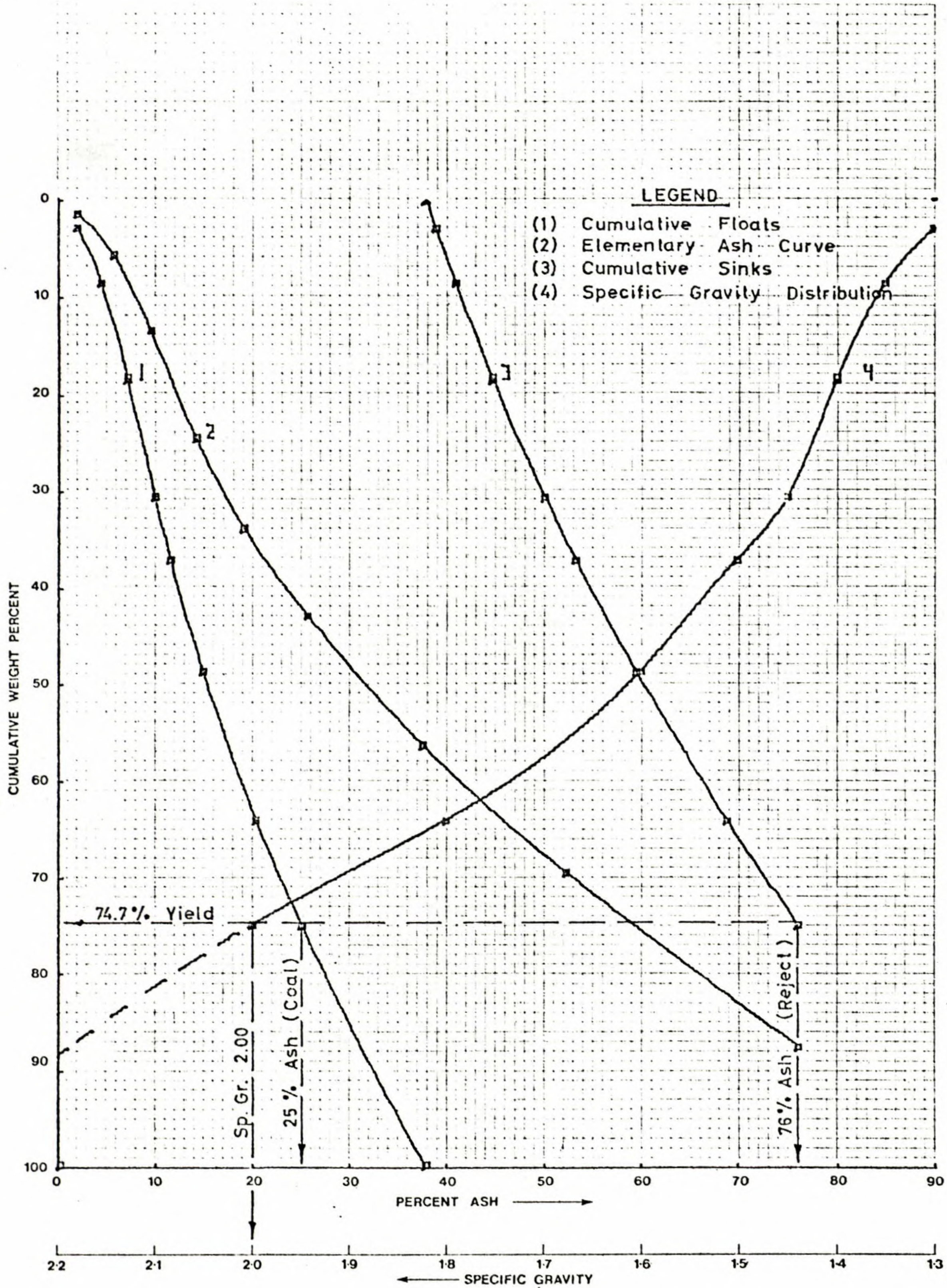

Figure 1: Kaiser Resources Ltd. - Lagoon C Refuse. Washability Curves for plus 150 mesh fraction (87.5% of total)

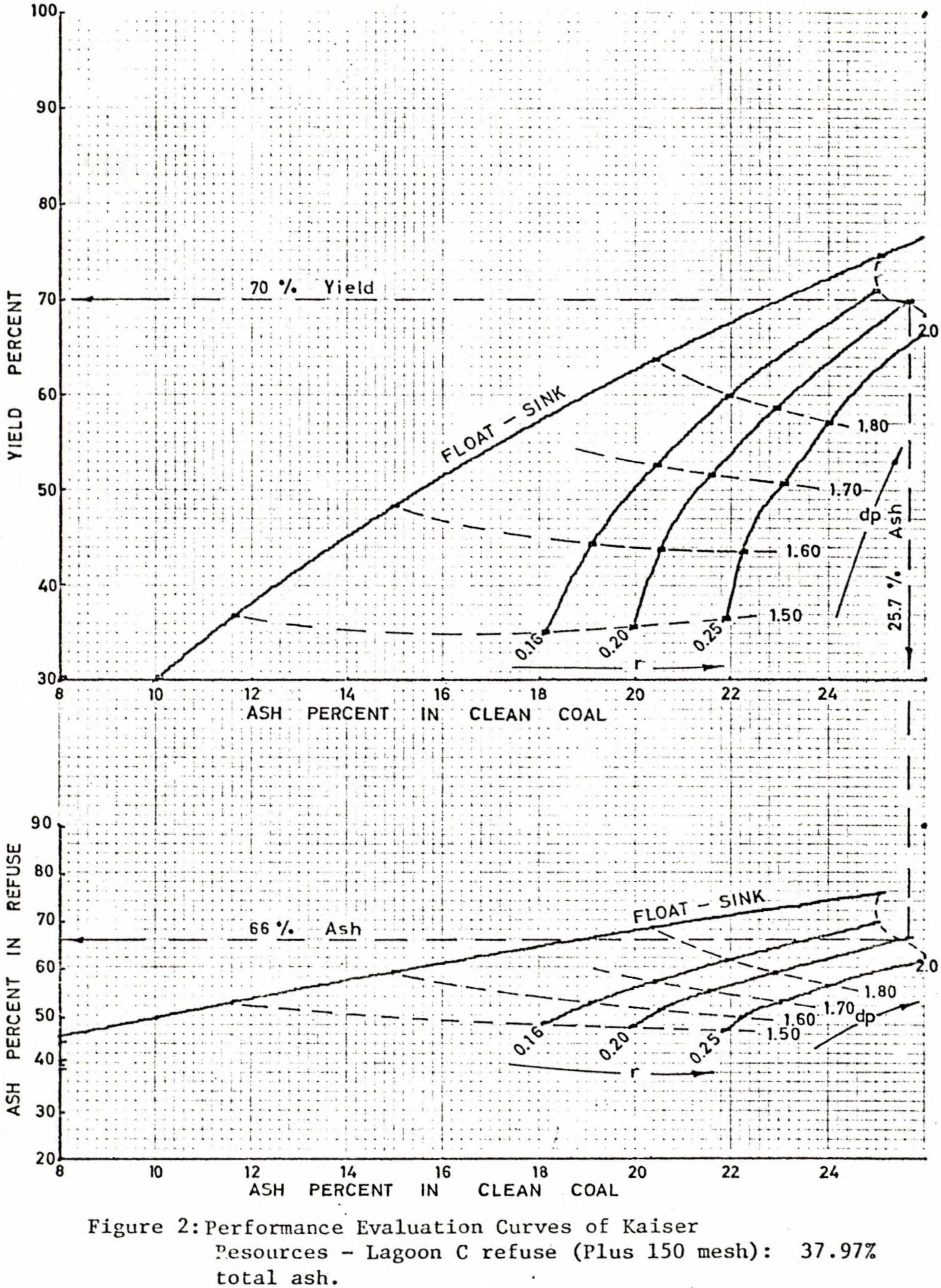

Figure 2: Performance Evaluation Curves of Kaiser Resources - Lagoon C refuse (Plus 150 mesh): 37.97% total ash.

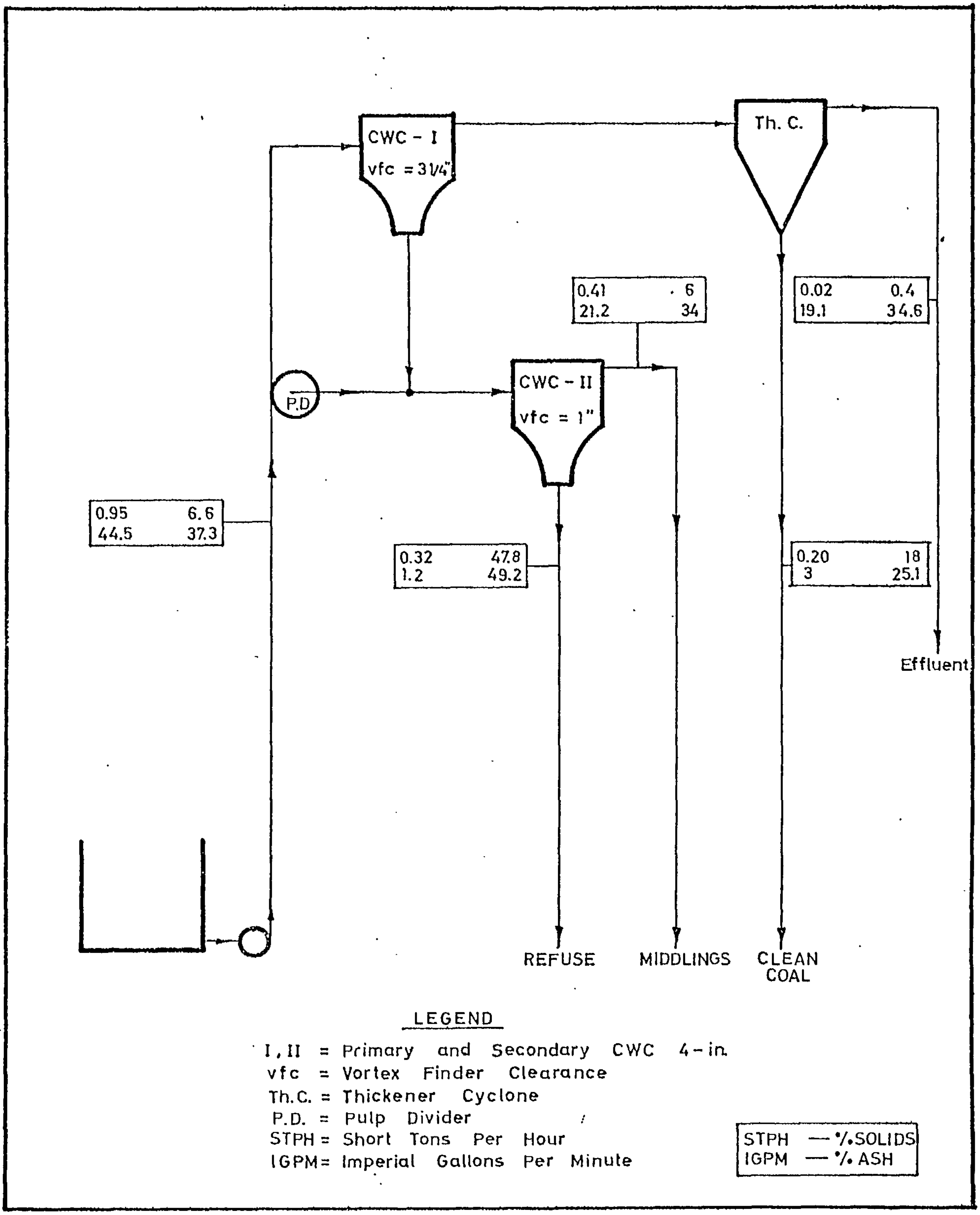

Figure 3: Data Flowsheet of the Two-stage CWC - 4-in. Test

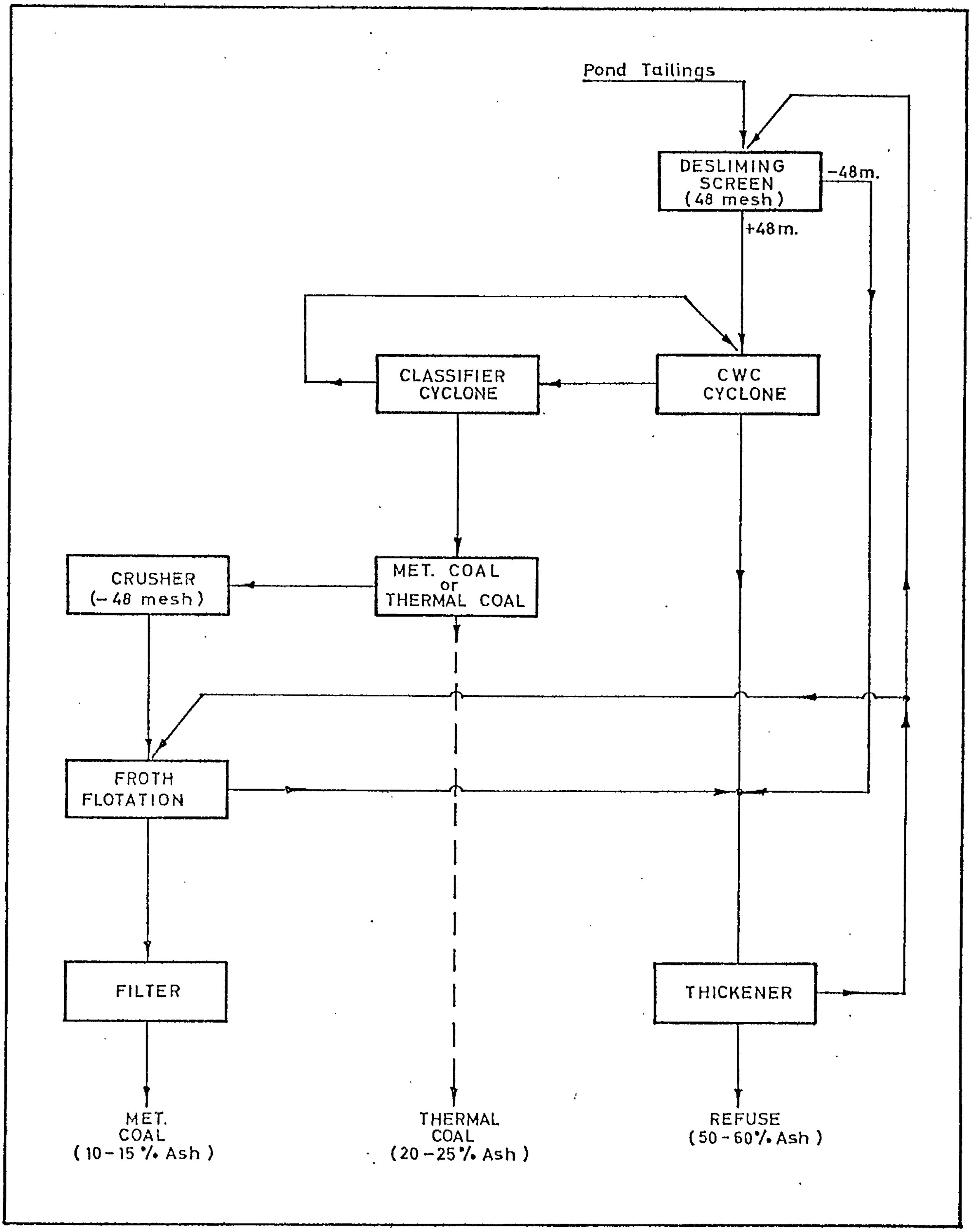

Figure 4: Proposed Flowsheet for the Recovery of Coal from Fine Refuse - Kaiser Resources.