DRY MAGNETIC SEPARATION OF ROD-MILL FEED AT MINNTAC PROGRESS REPORT NO. 1

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Summary

Pilot-plant testing at the Coleraine Research Laboratory has indicated the potential benefits of dry magnetic separation (cobbing) of Minntac rod-mill feed. Therefore, a prototype commercial unit was installed on line 18 to establish the benefits of dry cobbing. Line 18 was operated with and without dry cobbing on alternate days. The initial test period indicated, that for a short period and one splitter position, dry cobbing produced about a 5 percent increase in the magnetic iron tons in the wet cobber concentrate with a concurrent 2 percent loss in magnetic iron recovery. About 25 percent of that iron loss was associated with fine material being carried along with the dry cobber tailings. In the second test period, a flow meter and density guage were installed in the final concentrate line so that the actual long tons per hour of concentrate produced could be measured. The second test period ran for about 2 weeks and showed a production increase of about 3 percent with essentially no loss in magnetic iron recovery.

While the tests are not totally conclusive they do indicate potential benefits with dry cobbing. It is anticipated that with the recommended optimization of the splitter position and with the potential for increased iron recovery by screening the dry cobbing tailings that production increases of greater than the observed 3 percent will be realized.

(Discussion attached)

Discussion

Introduction

The purpose of dry cobbing is to remove low-grade material that normally would be rejected only after considerable size reduction. Pilot-scale tests[1,2]* indicated that 10 to 15 percent of the weight and about 2 to 3 percent of the magnetic iron could be removed by dry cobbing. The dry cobber tailings from the pilot tests were poorer liberating than the bulk feed sample. The effect of dry cobbing is to increase the rod-mill feed magnetic iron content about 2 percentage points and reduce the total tonnage of rod-mill feed about 10 to 15 percent. The lower tonnage in the rod mill should result in a finer grind which should carry throughout the system. Because the rod-mill discharge with dry cobbing would be higher grade and finer, both the weight and magnetic iron recovery in the wet cobbers should be higher. This higher magnetic iron recovery in the wet cobbers should compensate, at least partially, for the magnetic iron loss in the dry cobbing step. Therefore a line with dry cobbing should produce, for the same tonnage of new feed, a finer concentrate with lower silica than the same line without dry cobbing. However, since the Minntac control scheme is designed to produce a set grind and silica the effect of dry cobbing should appear as increased production.

To determine the effect of dry cobbing on a production line a prototype dry cobbing system was installed on line 18. The system is shown schematically on Figure 1. The normal rod-mill feed belt (023 belt) was shortened to allow the installation of the dry cobbing unit, which consists of a 48-inch-diameter by 84-inch-long belt-magnetic-head pulley and 24-inch-diameter by 84-inch-long tailing pulley about 25 feet apart and connected by a 6-foot-wide belt. The new feed discharges from the 023 belt onto a dead bed which spreads the feed evenly on the 6-foot-wide dry cobber belt to a depth of about one inch. The dry cobber belt accelerates the feed to about 550 feet per minute. As the material passes over the magnetic head pulley the magnetic material is pinned to the belt and travels around the pulley to the concentrate collection box while the weakly magnetic and nonmagnetic material are thrown away from the pulley. An adjustable splitter separates the tailing from the concentrate. The dry cobber tailing drop onto another belt equipped with a weightometer and a Ramsey coil for determining magnetic iron content. The dry cobber concentrate is washed into the rod mill.

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* See references.

Results

The dry cobbing unit was operational in March of 1986. During the initial break in of the dry cobbing unit, it was discovered that there was a discrepancy in the sampling. Extensively sampling of the rod-mill discharge on line 18 with and without dry cobbing indicated that the rod-mill discharge was consistantly 1 to 2 percentage points low in magnetic iron content as compared with the feed samples. The feed samples agreed well with the plant magnetic iron analyses on the feed belt. Rapid sampling of both the feed and the rod-mill discharge indicated that both samples were very reproducible which would tend to eliminate sampling procedure as the cause of the discrepancy. The "deacons" box (where the rod-mill discharge is sampled) on line 18 is lined with magnets to produce a protective lining of magnetite. Sampling of other lines where the deacons box is not lined with magnets indicated very good agreement between feed and rod-mill discharge samples. From this data it was concluded that the rod-mill discharge sample on line 18 was not reliable. Therefore, in this report all rod-mill discharge analysis are calculated from the magnetic iron content in the feed and dry cobber tailings and the plant weightometer readings for the feed and dry cobber tailings.

During the initial testing the effect of the splitter setting was established as shown in Figure 2. The numbers indicate various positions at which the splitter can be set with the higher numbers being closer to the magnetic head pulley. The splitter can not be set any closer than position 26 without interferring with the wash water addition.

To evaluate the dry cobbing it was decided to operate line 18 with and without dry cobbing on alternate days, to sample the system through the wet cobber magnetic separator, and to take final concentrate samples. Each day three sets of samples were taken at one-hour intervals, with the final concentrate samples being taken 30 minutes after the feed. In addition to the samples, normal plant data were collected as 30-minute averages by the computer. The testing was started on April 2 and ran through April 18 with dry cobbing being used on the even days. To operate the line without dry cobbing the dry cobbing tailings belt was shut off and the tailing material was allowed to accumulate in the tailing chute which forced all the feed into the rod mill.

The initial splitter setting was position 25 which based on earlier tests should have rejected about 11 percent of the weight (Figure 2). However, the first two days of dry cobbing operation indicated that the weight rejection was closer to 13 percent.

Therefore the splitter was changed to position 21. The reason for the change in weight rejection at a set splitter position is not entirely known but it appears to be related to the installation of a new 6-foot-wide belt on the dry cobber. The belt was changed just before the start of the test period. The new belt was 1/8-inch thicker than the old belt which may have changed the trajacotry of the particles and the field strength 1/8 inch futher from the magnetics may be sufficiently lower to allow more of the weakly magnetic particles to be rejected. Linear regressions relating weight rejection with magnetic iron content in the feed were run for the old belt at splitter position 25 and the new belt at splitter positions 25 and 21, Figure 3. These regressions indicate that changing the belt had a great impact on the weight rejection in the dry cobber step. The effect of splitter setting on weight rejection requires more investigation.

The results from the daily sampling of the line are given in Table I for days with dry cobbing and in Table II for days without dry cobbing. The average results for the daily samples for non-dry cobbing, and for dry cobbing at each splitter position are given in Tables III and IV, respectively. In addition to the daily samples the plant computer collected 30-minute averages of the feed rate to the line; the magnetic iron content of the feed; the long tons per hour and magnetic iron content of the dry cobber tailings; and the PSM percent minus 270 mesh in the final concentrate. The averages of the plant data for the periods without dry cobbing and with dry cobbing at both splitter positions along with an average of the daily laboratory silicas are given in Table V. A comparison of the plant measured magnetic iron content of the dry cobber tailings and the laboratory determined values, indicated that the plant measured values were consistantly high and seemed to vary with the loading on the dry cobber tailings belt. Two correlations were developed to adjust the plant magnetic iron content of the dry cobber tailings to the corresponding laboratory values. For splitter position 25 the regression equation is:

$$\text{Adjusted Value} = 0.985 \times \text{Plant Value} - 1.2056$$

The correlation coefficient (r) for this regression is 0.979. For splitter position 21 the regression equation is:

$$\text{Adjusted Value} = 0.4246 \times \text{Plant Value} - 1.2972$$

The r for this regression is 0.943.

The adjusted values of the magnetic iron content in the dry cobber tailings were used to calculate the magnetic iron recoveries shown in Table V. The adjusted values agree well with the recoveries determined by the sampling for a given weight rejection. The average weight rejection for splitter position 21 in the daily samples was 8.9 percent (Table IV) with a magnetic iron recovery of 98.3 percent as compared with 8.63 percent weight rejection and 98.37 percent magnetic iron recovery for the entire test period (Table V). Similarly for splitter position 25 the average weight rejection for the daily samples was 13.1 compared with 13.16 for the entire test period with corresponding magnetic iron recoveries of 97.1 and 96.73 percent. The good agreement between the daily samples and the plant data for the dry cobbing weight and magnetic iron recovery indicates that the weight and magnetic iron recoveries for the wet cobbers determined from the daily samples should be applicable to the plant data which should allow a better comparison of dry cobbing and non-dry cobbing. Using the average rod-mill feed tons and the dry cobber tailing weight and magnetic iron recovery from Table V along with the wet cobber weight and magnetic iron recoveries from Tables III and IV, the average tons per hour of magnetic iron in the wet cobber concentrate for the entire test period can be calculated as shown in Table VI. On this basis operating the line without dry cobbing produced on the average 87.12 LTPH of magnetic iron in the cobber concentrate compared with 86.67 LTPH with dry cobbing at splitter position 21 and 91.77 LTPH with dry cobbing at splitter position 25. While these results are far from conclusive, they do indicate that dry cobbing at least at splitter position 25, will result in increased production with some loss in magnetic iron.

Part of the magnetic iron loss is due to fine material sticking to the dry cobbing tailing particles. Screening the dry cobbing tailing from the daily samples at 10 mesh and analyzing the fractions for magnetic iron indicated that the tailings had about 6 percent by weight of minus 10-mesh particles which contained about 19 percent of the magnetic iron. The daily averages for the amount of minus 10-mesh material in the dry cobber tailings and the effect on overall iron and weight recovery of recovering the minus 10 mesh as concentrate is given in Table VII. Assuming that all of the minus 10-mesh material could be recovered by screening the tailing and that the minus 10-mesh material behaved the same as the bulk of the rod-mill discharge in the wet cobbers, then the estimated tons of magnetic iron in the cobber concentrate with dry cobbers at splitter position 21 increases to 86.94 LTPH and at splitter position 25 it increases to 92.3 LTPH.

Although not conclusive, the results obtained at a splitter setting of 25 were encouraging and indicated that more testing at position 25 was necessary. The next test series was run from May 27 to June 13 with daily switching from with dry cobbing to without dry cobbing. To better quantify the effects of dry cobbing a wedge flow meter and a density guage were temporarily installed in the final concentrate line so that the mass flow of final concentrate could be measured. There were no samples taken during this test period, only 30-minute averages of plant data were collected. The overall averages with and without dry cobbing are given in Table VIII. These results indicate that the use of dry cobbing produced an increase in line throughput, as measured by LTPH of final concentrate, of about three percent.

Conclusions and Recommendations

The results from the two test periods show that the use of dry cobbing will result in an increase in line production. An increase of about 3 percent was demonstrated over a short test period. This increase was obtained without optimization of the splitter position and without recovery of the minus 10-mesh material in the dry cobber tailings. It is recommended that the flow meter be re-installed in the final concentrate line and that more tests be conducted to better define the effects of splitter position and to establish the benefits of dry cobbing.

References

1. R. W. Salmi, "Test of a 48-Inch Diameter, 'Ore-Agitating', Short-Belt, High-Gradient Magnetic Head Pulley Separator on Minntac Rod-Mill Feed," Research Memorandum (1349), Ref. No. 03-B-590(008), April 10, 1984.

2. R. W. Salmi, "Short-Belt, 'Ore-Agitating', Axial-Pole, Permanent Magnet Head-Pulley Separator With a Short Magnet-Arc for Minntac Rod-Mill Feed," Research Memorandum (1370), Ref. No. 03-D-594(008), February 1, 1985.

Table I

Results of Daily Sampling With Dry Cobbing

Date	Dry Cobbing Step: Feed, LTPH	Mag Fe, %: Feed	Mag Fe, %: Tail	Mag Fe, %: RMD*	Mag Fe Recovery, %	Weight Rejection, %	Wet Cobbing Step: Mag Fe Recovery, %	Weight Recovery, %	Overall Through Wet Cobbing: Mag Fe Recovery, %	Weight Recovery, %
4/2 - 1**	490.03	20.9	4.75	23.2	97.1	12.6	95.95	65.55	93.16	57.29
2	473.10	21.3	4.46	23.8	97.3	12.7	96.22	64.37	93.61	56.20
3	486.17	21.4	4.42	24.2	97.1	14.0	96.54	66.84	93.74	57.48
4/4 - 1**	519.00	23.0	5.94	25.6	96.6	13.1	97.50	66.11	94.17	57.45
2	508.72	22.7	5.24	25.2	97.1	12.6	97.03	64.71	94.22	56.56
3	498.41	21.8	4.71	24.5	97.1	13.6	96.80	66.40	93.98	57.37
4/8 - 1	483.84	20.8	4.63	22.6	97.8	9.8	94.49	60.73	92.42	54.78
2	479.48	20.2	4.48	21.8	97.9	9.3	95.34	59.61	93.36	54.07
3	502.52	20.4	4.40	22.1	98.0	9.4	95.58	60.22	93.64	54.56
4/10 - 1	488.27	21.2	4.54	22.5	98.4	7.4	96.57	62.34	95.05	57.73
2	468.55	20.1	3.81	22.0	98.1	10.3	96.47	61.08	94.59	54.79
3	464.48	19.3	3.69	21.0	98.1	9.9	96.35	59.19	94.53	53.33
4/14 - 1	483.80	19.4	3.91	20.8	98.3	8.4	94.49	57.52	92.90	52.69
2	485.77	19.7	4.03	21.0	98.4	7.8	95.25	58.06	93.73	53.53
3	458.46	20.3	3.93	21.9	98.3	8.8	95.72	59.84	94.10	54.57
4/16 - 1	486.18	20.7	3.36	22.4	98.5	9.0	96.14	63.18	94.78	57.49
2	500.94	20.3	3.61	22.0	98.3	9.5	96.14	62.50	94.52	56.56
3	476.25	20.2	3.39	21.8	98.5	8.8	96.02	61.41	94.61	56.01
4/18 - 1	470.25	19.5	3.64	20.9	98.4	8.3	95.78	57.14	94.30	52.40
2	509.73	21.7	4.12	23.2	98.5	8.1	96.80	60.63	95.32	55.72
3	432.19	20.7	3.44	22.3	98.6	8.3	96.82	58.87	95.49	53.98

* Calculated from feed and tailing analysis plus weightometer weights.

** 4/4 and 4/8 samples with splitter at position 25.

Table II

Results From Daily Sampling Without Dry Cobbing

Date	Feed, LTPH*	Mag Fe, %	Wet Cobbing Mag Fe Recovery, %	Wet Cobbing Weight Recovery, %
4/3 - 1	499.41	20.8	95.9	59.40
2	499.90	20.4	96.2	58.20
3	499.64	20.7	95.4	58.40
4/7 - 1	464.15	22.0	96.0	57.23
2	484.52	21.9	96.0	56.22
3	503.12	20.8	95.1	53.60
4/9 - 1	453.73	20.6	94.0	54.73
2	493.11	20.4	96.1	55.96
3	510.53	20.6	96.2	56.46
4/11 - 1	381.81	19.6	95.2	54.87
2	504.43	19.7	95.8	57.12
3	468.89	20.5	95.3	56.47
4/15 - 1	471.12	20.5	95.0	58.32
2	480.94	21.2	95.9	58.40
3	462.81	21.0	96.0	60.01
4/17 - 1	474.04	21.0	96.1	58.84
2	465.57	19.7	96.0	55.32
3	413.77	19.6	96.0	52.86

* 5-minute average.

Table III

Average Results From Daily Samples Without Dry Cobbing

Date	LTPH	Mag Fe, %	Mag Fe Recovery, %	Weight Recovery, %
4/ 3	499.65	20.6	95.8	58.67
7	483.93	21.6	95.7	55.68
9	485.79	20.5	95.4	55.72
11	451.71	19.9	95.4	56.15
15	471.62	20.9	95.6	58.91
17	451.13	20.1	96.0	55.67
Average	473.97	20.6	95.7	56.80

Table IV

Average Results From Daily Samples With Dry Cobbing

Date	Dry Cobbing Step						Wet Cobbing Step		Overall Through Wet Cobber	
	Feed, LTPH	Mag Fe, %			Mag Fe Recovery, %	Weight Rejection, %	Mag Fe Recovery, %	Weight Recovery, %	Mag Fe Recovery, %	Weight Recovery, %
		Feed	Tail	RMD						
4/2	483.10	21.2	4.54	23.73	97.2	13.1	96.24	65.59	93.50	56.99
4/4	508.71	22.5	5.30	25.10	96.9	13.1	97.11	65.74	94.12	57.13
4/8	488.61	20.5	4.50	22.17	97.9	9.5	95.14	60.19	93.14	54.47
4/10	473.77	20.2	4.01	21.83	98.2	9.2	96.46	60.87	94.72	55.28
4/14	476.01	19.8	3.96	21.23	98.3	8.3	95.15	58.47	93.58	53.60
4/16	487.78	20.4	3.45	22.07	98.4	9.1	96.10	62.36	94.62	56.69
4/18	470.72	20.6	3.73	22.13	98.5	8.2	96.47	58.80	95.04	54.03
Avg Splitter 25	495.91	21.85	4.92	24.42	97.1	13.1	96.68	65.66	93.81	57.06
Avg Splitter 21	479.38	20.3	3.93	21.89	98.3	8.9	95.86	60.14	94.22	54.81

Table V

Average Values of Plant Data for Entire Test Period

	Without Dry Cobbing	With Dry Cobbing	
		Splitter 21	Splitter 25
Rod-Mill Feed, LTPH	454.07	458.45	489.47
% Mag Fe	20.62	20.28	20.51
PSM, % Minus 270 Mesh	87.71	88.13	86.70
Lab SiO_2, %	5.00	4.93	5.25
Dry Cobber Tailing			
Weight Rejection, %		8.63	13.16
Mag Fe Recovery, %*		98.37	96.73

* Adjusted to Davis-tube magnetic iron.

Table VI

Average LTPH of Magnetic Iron in Wet Cobber Concentrate

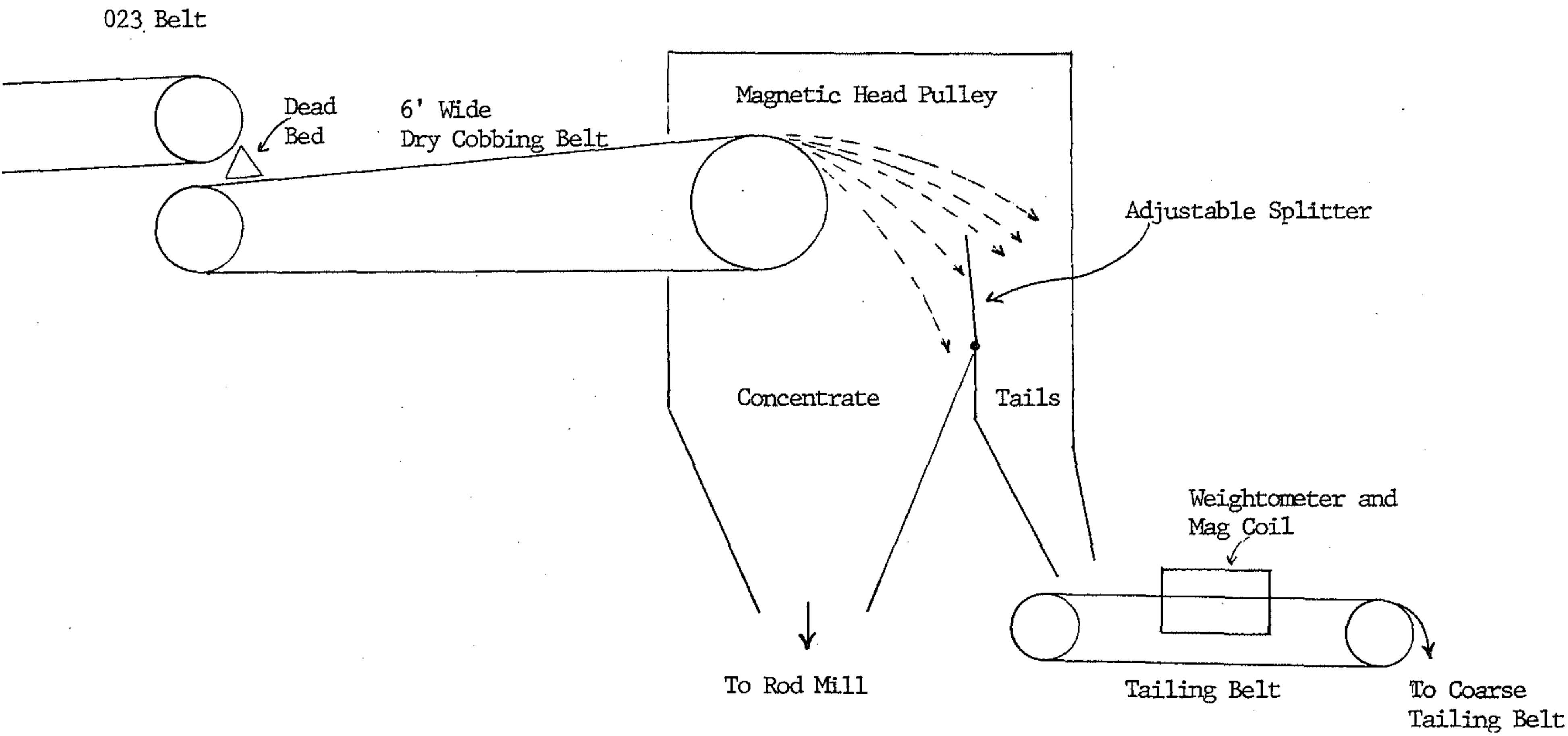
	Without Dry Cobbing	With Dry Cobbing	
		Splitter 21	Splitter 25
Rod-Mill Feed, LTPH*	440.08	448.36	478.70
Mag Fe in Feed, LTPH**	91.04	91.91	98.13
Mag Fe in Cobber Concentrate, LTPH	87.12	86.67	91.77

* Dry basis assuming 2.2 percent moisture in feed.
** Assume 20.5 percent magnetic iron for all cases.

Table VIII

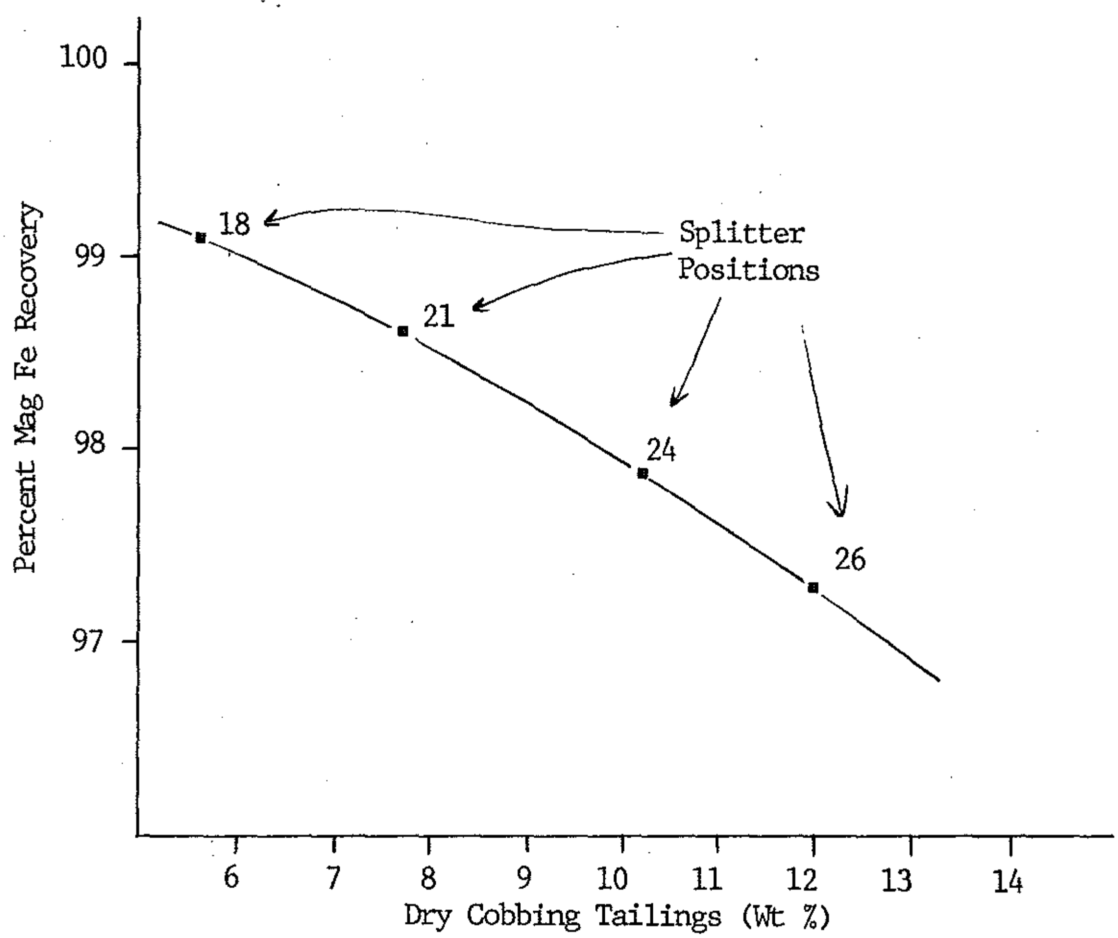
Results of June 1986 Tests

	Without Dry Cobbing	With Dry Cobbing Position 25
Line Feed, NLTPH	468.65	475.63
Magnetic Iron, %	19.93	20.12
Magnetic Iron, LTPH	93.38	95.70
Dry Cobber Tailings Weight Rejection, %	-	10.00
Final Concentrate		
LTPH	115.85	119.17
Weight Recovery, %	24.72	25.10
SiO_2, %	5.28	5.30
PSM, % -270 Mesh	87.80	88.00
Magnetic Iron Recovery, %	85.64	86.03



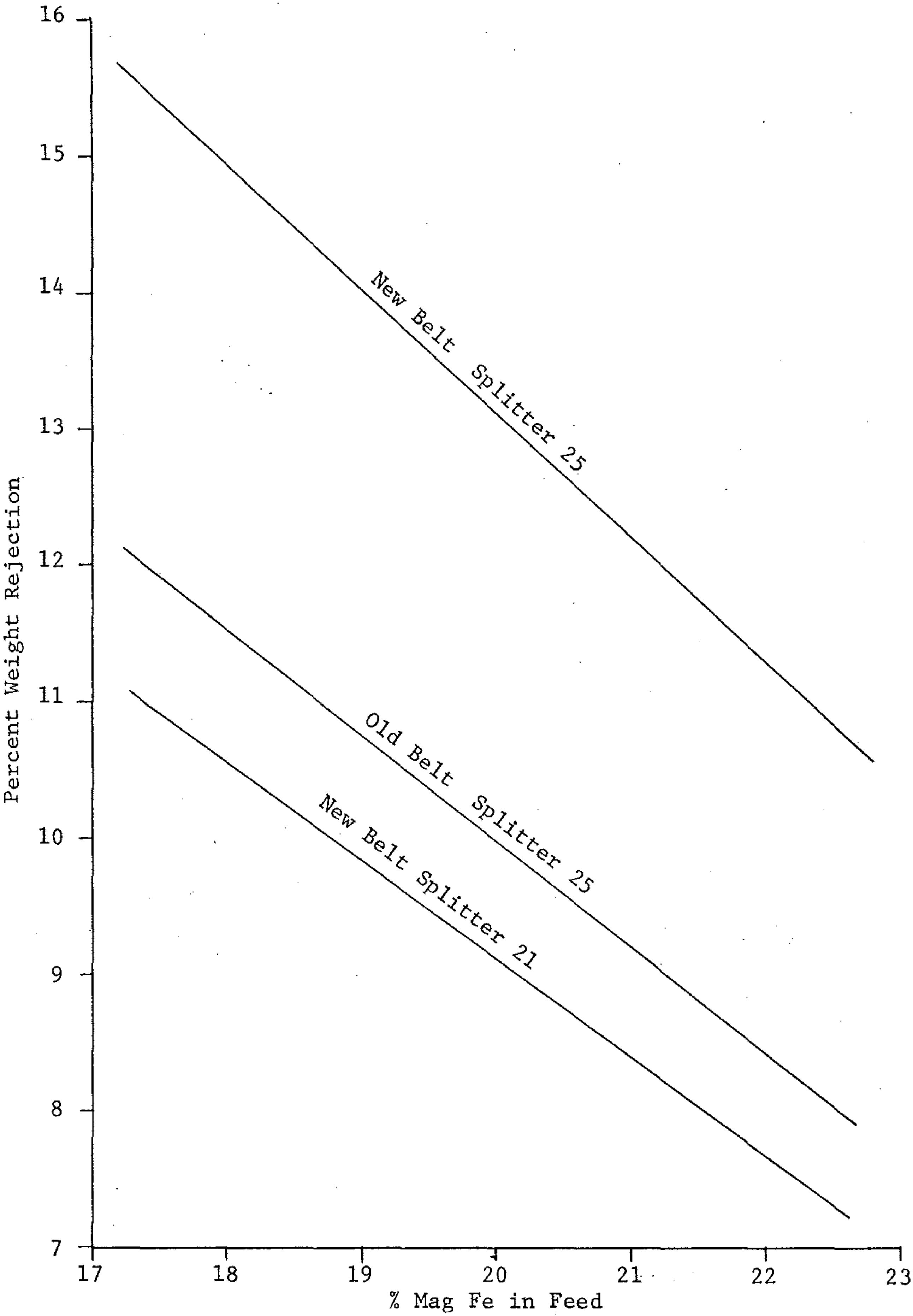
SCHEMATIC OF DRY COBBING INSTALLATION ON LINE 18

Figure 1



EFFECT OF SPLITTER POSITION ON
MAG FE RECOVERY AND WEIGHT REJECTION

Figure 2



COMPUTER REGRESSION OF PLANT DATA RELATING
% WEIGHT REJECTION TO MAG FE IN THE FEED FOR
DIFFERENT BELTS AND SPLITTER SETTINGS

Figure 3