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# PILOT PLANT INVESTIGATION ON SAMPLES OF PHILLIPINE CHROME ORE FINES SUBMITTED BY CANADIAN REFRACTORIES LIMITED

by

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MINERAL PROCESSING DIVISION

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## SUMMARY OF RESULTS

Pilot plant tests were carried out on chrome ore fines from 28 mesh screening of Phillipine chrome ore at Canadian Refractories Limited. Results are tabulated below:

| Description of Test and Products | Weight Recovery % | Analysis % $SiO_2$ |
|---|---|---|
| 1. Gravity conc of screen fractions: | | |
| -28+60m conc on Wemco-Remer jig | 48.7 | 2.03 |
| -60m conc on Deister table | 26.7 | 2.47 |
| Combined concentrates | 75.4 | 2.19 |
| 2. Humphreys spiral concentration: | | |
| -28m (incl -60m) | 61.4 | 2.00 |
| 3. High intensity magnetic separation: | | |
| -28+60m Dings (dry) | 50.8 | 2.9 |
| -28+60m Wetherill (dry) | 53.1 | 2.3 |
| -28m (incl -60m) Jones (wet) | 92.3 | 2.3 |

A second sample of chrome ore fines was treated by dry high intensity magnetic separation methods but the results were not as good due to a greater percentage of fines.

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# INTRODUCTION

## Purpose of Investigation

A request for pilot plant scale tests on -28 mesh chrome ore fines was made by Mr. L. Hodnett, Asst Technical Director, Canadian Refractories Ltd., Canada Cement Building, Montreal 2, P.Q. and confirmed in his letter of August 20th, 1965. He asked if the results obtained on the -28+60 mesh fraction of chrome ore fines using the Denver 4 in. x 6 in. pilot plant jig, reported in Mines Branch Report IR 66-12, could be duplicated with the Wemco-Remer pilot plant jig. The -60 mesh size fraction to be treated by tabling. The combined jig and table concentrates sent to the Marelan Works of Canadian Refractories Ltd. for testing and evaluation.

Additional tests were requested to treat the -28 mesh chrome ore fines using a Humphreys spiral, and by wet and dry high intensity magnetic separation methods.

## Shipment

A shipment consisting of 10 tons of -28 mesh Phillipine chrome ore fines together with 200 lb of lump chrome ore was received on September 27, 1965. The chrome ore fines identified as C.R.L. Project 4874 were for pilot plant scale tests and the lump chrome ore for use as ragging for the jig. A second shipment of 500 lb of -28 mesh chrome ore fines was received on November 16, 1965 for additional beneficiation tests and identified as C.R.L. Project 4969.

The shipments were submitted by Mr. L. W. Lorimer, Research Department, Canadian Refractories Ltd., Marelan Plant, Grenville, P.Q.

## Analysis

Chemical analyses for the jigging, tabling, and high intensity dry magnetic separation tests on the 10 ton pilot mill run ore were made at the Research Laboratories of Canadian Refractories Ltd., Grenville, P.Q. by arrangement with Mr. L. Hodnett.

Chemical analyses for all the other tests were made by the Analytical Chemistry Subdivision of the Mineral Sciences Division, Mines Branch.

## DETAILS OF TEST WORK

### Tests on the 10 ton Sample C.R.L. Project 4874

A head sample was split out of the shipment received and a screen test made. Results are shown in Table 1.

TABLE 1

Screen Test of -28 mesh Chrome Ore Fines

| Mesh Tyler | Weight % |
|---|---|
| + 28 | 0.0 |
| - 28+ 35 | 13.2 |
| - 35+ 48 | 16.9 |
| - 48+ 65 | 17.3 |
| - 65+100 | 14.0 |
| -100+150 | 12.5 |
| -150+200 | 5.7 |
| -200+325 | 7.5 |
| -325 | 12.9 |
| Total | 100.0 |

### Dry and Wet Screening

A sample of fines was dry screened on a Rotex screen equipped with a 60 mesh (0.0097 in. opening) screen cloth and the plus 60 mesh size fraction used for preliminary jigging tests. Due to adhering fines, left after dry screening, it was difficult to obtain visual control of the jig operation and so the remaining sample used for the jigging tests was wet screened on 60 mesh. The wet and dry -60 mesh size fractions were treated separately. Results of the dry and wet screening are shown in Table 2.

TABLE 2

Results of Dry and Wet Screening on 60 mesh

| Product | Weight % |
|---|---|
| Dry screening | |
| -60 mesh | 36.8 |
| Wet screening | |
| +60 mesh | 57.4 |
| -60 mesh | 5.8 |
| Total | 100.0 |

## Gravity Concentration

### Jigging Tests

Preliminary tests were made with the Wemco-Remer pilot plant jig to determine the most promising operating conditions for producing an acceptable concentrate from the -28 + 60 mesh size fraction. The operating factors changed included the speed and length of the stroke for the primary eccentric, the amount of bottom and top water to control the degree of suction, the diameter of the spigot openings from the hutches, the slope of the jig, the feed rate, and the jig bed. The different kinds of ragging which were tried for the jig bed included -1/4 in. + 8 mesh chromite, -7/16 in. + 1/4 in. iron concentrate pellets, 3/8 in. and 3/16 in. steel balls and -3/16 + 8 mesh nickel shot.

The operating conditions which gave visually an acceptable concentrate are shown in Table 3. Test results of treating the -28 + 60 mesh size fraction under these operating conditions are shown in Table 4.

TABLE 3

Wemco-Remer Pilot Plant Jig Operating Conditions

| | | |
|---|---|---|
| Primary eccentric | 3/16 in. stroke at 180 rpm | |
| Secondary eccentric | 1/16 in. stroke at 470 rpm | |
| Ragging | 3/8 in. steel shot | 51.4% |
| | 3/16 in. steel shot | 23.5% |
| | -3/16 in. + 8 mesh nickel shot | 25.1% |
| | Total 255 lb | 100.0% |
| Bed depth | | |
| Nos 1, 2 and 3 Hutches | 3½ in. | |
| No. 4 Hutch | 2½ in. | |
| Supporting screen | 14 mesh | |
| Discharge spigots | 3/8 in. diam | |
| Water | 56.8 imp. gals per min | |
| Slope of jig | 1 in. per ft | |
| Feed Rate | 3,000 lb per hr | |

TABLE 4

Results of Jigging the +60 mesh Size Fraction

| Product | Weight % | | Analysis |
|---|---|---|---|
| | Test | Original | % $SiO_2$ |
| No. 1 Hutch | 12.8 | 7.3 | 1.85 |
| No. 2 Hutch | 14.0 | 8.0 | 1.95 |
| No. 3 Hutch | 21.6 | 12.4 | 2.00 |
| No. 4 Hutch | 36.5 | 21.0 | 2.15 |
| Gate | 3.5 | 2.0 | 5.85 |
| Tailing | 11.6 | 6.7 | 7.90 |
| Feed (calcd) | 100.0 | 57.4 | 2.85 |
| Comb hutch conc | 84.9 | 48.7 | 2.03 |
| Comb gate and tailing | 15.1 | 8.7 | 7.43 |
| Total | 100.0 | 57.4 | 2.85 |

Tabling Tests

The -60 mesh size fraction from the dry screening of the -28 mesh fines and the -60 mesh size fraction from the wet screening of the +60 mesh dry screened fines were treated separately on a No. 14 Deister concentrating table.

The table was operated for both tests at 370 rpm with a stroke of 9/16 in. and about 11.0 imp gals per min of wash water. Feed rate was 360 lb per hr for the -60 mesh dry screened material and 500 lb per hour for the wet screened material, the middlings were returned to the feed for both tests.

Results of the table tests are shown in Table 5.

TABLE 5

Results of Tabling the -60 mesh Size Fraction

| Product | Weight % | | Analysis |
|---|---|---|---|
| | Test | Original | % $SiO_2$ |
| -60 mesh dry screening | | | |
| Table conc | 58.4 | 21.5 | 2.55 |
| Table tailing | 41.6 | 15.3 | 8.55 |
| Feed (calcd) | 100.0 | 36.8 | 5.04 |
| -60 mesh wet screening | | | |
| Table conc | 89.4 | 5.2 | 2.15 |
| Table tailing | 10.6 | 0.6 | 10.35 |
| Feed (calcd) | 100.0 | 5.8 | 3.02 |
| Comb table conc | | 26.7 | 2.47 |
| Comb table tailing | | 15.9 | 8.62 |
| Total (calcd) | | 42.6 | 4.76 |

Results of combining the jigging and tabling tests are shown in Table 6.

TABLE 6

Results of the Combined Jigging and Tabling Tests

| Product | Weight % | Analysis % $SiO_2$ |
|---|---|---|
| Jig conc | 48.7 } 75.4 | 2.03 } 2.19 |
| Table conc | 26.7 | 2.47 |
| Jig & table tailing | 24.6 | 8.20 |
| Feed (calcd) | 100.0 | 3.67 |
| (assay) | | 3.70 |

Humphreys Spiral Tests

A sample of the +60 mesh size fraction was treated in a Model 24-A Humphreys spiral at 1250 lb per hour with a 3 to 1 water to solids ratio. Results of the test are shown in Table 7.

TABLE 7

Results of a Humphreys Spiral Test on the -28+60 Mesh Size Fraction

| Product | Weight % | | Analysis % $SiO_2$ |
|---|---|---|---|
| | Test | Original | |
| Spiral conc | 80.5 } 84.6 | 46.2 } 48.6 | 2.12 } 2.16 |
| Spiral middling | 4.1 | 2.4 | 2.99 |
| Spiral tailing | 15.4 | 8.8 | 6.04 |
| Feed (calcd) | 100.0 | 57.4 | 2.76 |

Because of the promising results in treating the +60 mesh material it was decided to treat a sample of the chrome ore fines as received under similar operating conditions. Results of the test are shown in Table 8.

TABLE 8

Results of Humphreys Spiral Test on -28 Chrome Ore Fines

| Product | Weight % | | Analysis % $SiO_2$ | |
|---|---|---|---|---|
| Spiral conc | 56.1 | 61.4 | 2.0 | 2.0 |
| Spiral middling | 5.3 | | 2.3 | |
| Spiral tailing | 38.6 | | 6.4 | |
| Feed (calcd) | 100.0 | | 3.7 | |
| (assay) | | | 3.9 | |

High Intensity Magnetic Separation

Dings Induced Roll Dry Magnetic Separator Tests

A sample of the +60 mesh size fraction was treated by a Dings, Type IR, 3 roll magnetic separator. The magnetic separator was operated at 6.0 amp, and a feed rate of 125 lb/ in. of roll/hr. Results of the test are shown in Table 9.

TABLE 9

Results of Dings Type IR Magnetic Separator Test

| Product | Splitter Gap | Weight % | | | | Analysis % $SiO_2$ | |
|---|---|---|---|---|---|---|---|
| | | Test | | Original | | | |
| 1st Roll | 3/4 in. | 8.1 | 81.4 | 4.6 | 46.8 | 3.5 | 2.8 |
| 2nd Roll | 3/4 in. | 54.8 | | 31.5 | | 2.7 | |
| 3rd Roll | 5/8 in. | 26.6 | | 15.3 | | 3.1 | |
| Tailing | | 10.5 | | 6.0 | | 5.8 | |
| Feed (calcd) | | 100.0 | | 57.4 | | 3.2 | |
| (assay) | | | | | | 3.3 | |

A further test was made at a lower feed rate of 25 lb/in. of roll/hr at the same field strength and roll speed but with different splitter positions to improve the separation. Results of the test are shown in Table 10.

TABLE 10

Results of Dings Type IR Magnetic Separator Test

| Product | Splitter Gap | Weight % | | Analysis % SiO |
|---|---|---|---|---|
| | | Test | Original | |
| 1st Roll | 1 1/4 in. | 57.1 } 88.5 | 32.8 } 50.8 | 2.2 } 2.9 |
| 2nd Roll | 5/8 in. | 31.4 | 18.0 | 4.1 |
| 3rd Roll | 11/16 in. | 8.6 | 4.9 | 3.9 |
| Tailing | | 2.9 | 1.7 | 19.4 |
| Feed (calcd) | | 100.0 | 57.4 | 3.4 |
| (assay) | | | | 3.3 |

Wetherill Cross Belt Type Dry Magnetic Separator Test

A sample of the +60 mesh size fraction was treated by a Wetherill cross belt type magnetic separator at 200 lb/per hour. Results of the test are shown in Table 11.

TABLE 11

Results of Wetherill Cross Belt Separator Test

| Product | Amps | Gap | Weight % | | Analysis % $SiO_2$ |
|---|---|---|---|---|---|
| | | | Test | Original | |
| 1st Cross belt | 6.5 | 3/8 in. | 0.5 | 0.3 | 6.9 |
| 2nd Cross belt | 9.0 | 1/4 in. | 1.5 } 92.5 | 0.9 } 53.1 | |
| 3rd Cross belt | 11.0 | 1/4 in. | 91.0 | 52.2 | 2.3 |
| Tailing | | | 7.0 | 4.0 | 11.3 |
| Feed (calcd) | | | 100.0 | 57.4 | 3.3 |
| (assay) | | | | | 3.3 |

Jones Laboratory High Intensity Wet Magnetic Separator Tests

A 2,000 gram sample of the -28 mesh chrome ore fines as received was treated in a Jones laboratory high intensity wet magnetic separator. The sample was first treated at 0 amp, to remove any highly magnetic material which may have blocked the plates, and then treated at 25 amps. The middlings were repassed

at 25 amps. Results of the test are shown in Table 12.

TABLE 12

Results of Jones Laboratory Wet Magnetic Separator Tests

| Product | Weight % | | Analysis % $SiO_2$ | |
|---|---|---|---|---|
| Mag conc 0 amps | 4.2 | 92.3 | 2.7 | 2.3 |
| 1st Mag conc 25 amps | 72.4 | | 2.2 | |
| 2nd Mag conc 25 amps | 15.7 | | 2.9 | |
| 2nd Middling | 2.4 | | 13.5 | |
| 1st Non mag | 1.1 | | 18.3 | |
| 2nd Non mag | 4.2 | | 23.1 | |
| Feed (calcd) | 100.0 | | 3.7 | |
| (assay) | | | 3.8 | |

Tests on the 500 lb Sample C.R.L. Project 4969

A head sample was riffled out of the 500 lb shipment received and a screen test made. Results are shown in Table 13.

TABLE 13

Screen Test of -28 Mesh Chrome Ore Fines

| Mesh Tyler | Weight % |
|---|---|
| + 28 | 3.6 |
| - 28+ 35 | 7.2 |
| - 35+ 48 | 9.9 |
| - 48+ 65 | 9.9 |
| - 65+100 | 11.0 |
| -100+150 | 11.3 |
| -150+200 | 6.6 |
| -200+325 | 8.9 |
| -325 | 31.6 |
| Total | 100.0 |

Dry Screening

The 500 lb sample was split into two lots. One lot was dry screened on 60 mesh and the other on 100 mesh for high intensity dry magnetic separation tests.
Screening results were: (1) retained on 60 mesh 40.9%
and (2) retained on 100 mesh 50.8%

## Wetherill Cross Belt Type Dry Magnetic Separator Tests

Samples of the +60 and +100 mesh size fractions were treated by a Wetherill cross belt magnetic separator at 200 lb per hour. Results of the tests are shown in Table 14.

TABLE 14

Results of Wetherill Cross Belt Separator Tests

| Product | Amps | Gap | Weight % Test | | Weight % Original | | Analysis % $SiO_2$ | |
|---|---|---|---|---|---|---|---|---|
| +60 mesh size fraction | | | | | | | | |
| 1st Cross belt | 6.5 | 3/8 in. | 0.5 | | 0.2 | | 9.1 | |
| 2nd Cross belt | 8.5 | 1/4 in. | 11.5 | 89.6 | 4.7 | 36.6 | 1.9 | 2.6 |
| 3rd Cross belt | 11.0 | 1/4 in. | 78.1 | | 31.9 | | 2.7 | |
| Tailing | | | 9.9 | | 4.1 | | 20.4 | |
| Feed (calcd) | | | 100.0 | | 40.9 | | 4.4 | |
| (assay) | | | | | | | 4.3 | |
| +100 mesh size fraction | | | | | | | | |
| 1st Cross belt | 6.5 | 3/8 in. | 0.5 | | 0.3 | | 15.1 | |
| 2nd Cross belt | 8.5 | 1/4 in. | 13.8 | 88.2 | 7.0 | 44.8 | 2.2 | 2.4 |
| 3rd Cross belt | 11.0 | 1/4 in. | 74.4 | | 37.8 | | 2.4 | |
| Tailing | | | 11.3 | | 5.7 | | 18.3 | |
| Feed (calcd) | | | 100.0 | | 50.8 | | 5.2 | |
| (assay) | | | | | | | 5.9 | |

## Dings Induced Roll Dry Magnetic Separator Tests

A sample of the +60 mesh size fraction was treated by the Dings Type IR 3 roll magnetic separator. The magnetic separator was operated at 6.0 amp with a feed rate of 25 lb/in. of roll/hr. Results of the test are shown in Table 15.

TABLE 15

Results of Dings Type IR Magnetic Separator Tests

| Product | Splitter Position | Weight % Test | | Weight % Original | | Analysis % $SiO_2$ | |
|---|---|---|---|---|---|---|---|
| 1st Roll | -3/4 | 37.5 | | 15.3 | | 3.1 | |
| 2nd Roll | -1 1/2 | 36.3 | 90.0 | 14.9 | 36.8 | 3.3 | 3.2 |
| 3rd Roll | +1 | 16.2 | | 6.6 | | 3.2 | |
| | | 10.0 | | 4.1 | | 12.86 | |
| Feed (calcd) | | 100.0 | | 40.9 | | 4.2 | |
| (assay) | | | | | | 4.3 | |

## DISCUSSION OF RESULTS

The results of the pilot plant scale tests with a Wemco-Remer pilot plant jig and a Deister table showed that the -28 chrome ore fines could be upgraded to yield a combined jig and table concentrate containing 2.19% $SiO_2$ with a weight recovery of 75.4% of the original feed.

A test treating the chrome ore fines as received with a Humphreys spiral produced a concentrate containing 2.0% $SiO_2$ with a 61.4% weight recovery, which probably could be increased with additional test work. The use of spirals as compared with the combined use of screens, jigs, and tables would offer a simpler operation.

Tests treating the +60 mesh size fraction with a pilot plant size Wetherill cross belt high intensity dry magnetic separator, and a Dings induced roll high intensity dry magnetic separator showed that the Wetherill separator gave the better result. The Wetherill separator produced a concentrate containing 2.3% $SiO_2$ with an overall weight recovery of 53.1% compared with the Dings separator which produced a concentrate containing 2.9% $SiO_2$ with an overall weight recovery of 50.8%.

The dry magnetic separation processes require the removal of fines with a resulting decrease in overall recovery. The decrease in recovery will vary with the amount of fines removed. In treating the second shipment of fines although the test recoveries were about the same as with the first shipment the overall recoveries were lower due to the greater amount of fines removed. Recovery could be increased without increasing the $SiO_2$ content by removing only the -100 mesh fines instead of the -60 mesh fines.

The grade of concentrate produced and the recovery differed in the tests on the two shipments submitted. These variations were due to the difference in grade and the size distribution of the material. In a full scale operation these variations could be eliminated by blending the feed. Without a uniform feed, close control of the operation will be required to obtain a constant grade of concentrate.

The best results were obtained using the Jones laboratory wet high intensity magnetic separator on the -28 mesh feed as received. A concentrate was produced containing 2.3% $SiO_2$ with a weight recovery of 92.3% of the original feed.

GWR/lm