CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 61-66

CRUSHING TESTS ON A SAMPLE OF CLINOPTILOLITE SUBMITTED BY ATOMIC ENERGY OF CANADA LIMITED, CHALK RIVER, ONTARIO

by

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MINERAL PROCESSING DIVISION

COPY NO. 18

JUNE 26, 1961

CONTENTS

Industrial Confidential

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T. F. Berry*

SUMMARY OF RESULTS

A recovery of 52.0% of the -14 +65 mesh material was realized in the mill run.

The nature of the material was such that dust losses were high, being estimated at 10% of the entire shipment.

A typical screen analysis on the finished product was as follows:

Size	Weight %
+14 mesh	2.6
-14 +65 "	92.8
-65 "	4.6
Total	100.0

A flowsheet designed to meet the requirements of the proposed crushing and grinding operation at Chalk River is illustrated in the conclusions of this report.

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INTRODUCTION

The Atomic Energy of Canada Limited propose to use the zeolite mineral clinoptilolite in an ion exchange operation to remove radioactive strontium and cesium from solutions. The size range of the mineral, based on considerations of the kinetics of the exchange reaction and of the flow characteristics of the bedded material was suggested as -14 +65 mesh.

Nature of Investigation

Mr. L. C. Watson of the Chemical Engineering Branch, Chemistry and Metallurgy Division, Atomic Energy of Canada Limited, Chalk River, Ontario, in a letter dated May 2, 1961, requested crushing and grinding tests on this material to determine the optimum recovery which might be expected in producing a finished product having a size range of -14 +65 mesh. He also asked that a recommendation be made concerning the type of equipment best suited for this purpose.

Shipments

A sample of clinoptilolite weighing 100 lb was received on May 18, 1961, for preliminary crushing and grinding tests. A second shipment, weighing 5 tons, was received on June 9, 1961, from the Baroid Division, National Lead Company Limited, Newberry, California. Mr. Watson asked that the products, both +65 mesh and -65 mesh, be returned to the Atomic Energy of Canada Limited at Chalk River, Ontario.

DETAILS OF INVESTIGATION

On the initial 100 lb sample which was received, small scale crushing tests were carried out using a Peacock gyratory crusher, a set of Sturtevant rolls and a small laboratory jaw crusher.

In one of these tests a very careful crushing program was done using a small laboratory jaw crusher. The mineral was crushed to -1 in. in a jaw crusher and then fed into the small jaw crusher with an initial setting of ½ in. A 14 mesh vibrating screen was placed in closed circuit with this crusher and six passes of the screen oversize were necessary to reduce the material to all -14 mesh. The final setting of the crusher was 1/16 in. The -14 mesh material was sampled and a screen test on the material was as follows:

TABLE 1

Result of Jaw Crusher Test

Mesh Size	Weight %	% Passing
+ 6 mesh	-	100.0
-6 + 8 "	0.4	99.6
-8 +10 "	1.0	98.6
-10 +14 "	1.5	97.1
-14 +20 "	14.6	82.5
-20 +28 "	14.7	67.8
-28 +35 "	12.2	55.6
-35 +48 "	9.4	46.2
-48 +65 "	9.2	37.0
-65 "	37.0	
Total	100.0	

With this test as an example, it was realized that it would be difficult to obtain a true picture of the crushing characteristics of clinoptilolite until the 5-ton shipment was available for testing in mill-sized pieces of equipment.

On the arrival of the larger shipment several preliminary tests were done using a Hazemag impact crusher and a C.E.I. No. BS502 gyratory crusher each in closed circuit with a vibrating screen.

Hazemag Impact Crusher (Preliminary)

In this crusher, the mineral entering the crushing chamber is picked up by bars attached to a fast revolving drum and thrown against a striker plate. Experience has shown that the variable most influencing the degree of comminution is the speed of the rotor with the gap between the rotor bars and the striker plates having a less marked effect.

Thus, with this gap opening set at the maximum, the speed of the rotor was varied in order to determine the best operating conditions. A 4 and 8 mesh screen was alternately placed in closed circuit with the crusher.

During each test approximately 300 lb of the mineral was fed into a jaw crusher set at 2 in. The crusher discharge passed through a Symons cone crusher and thence to the impact crusher. The Hazemag crusher discharged to a vibrating screen with the screen oversize being returned to the circuit. Since the object of the tests was to determine the amount of -65 mesh material in the screen undersize, a sample of this material was riffled out when the circuit had reached steady operating conditions. The results of these preliminary tests on this crusher may be seen in the following table with the conditions prevailing during each test.

TABLE 2

Results of Preliminary Hazemag Crushing Tests

Mesh Size	Weight %	% Pass	Weight %	% Pass	Weight %	% Pass	Weight %	% Pass
+4 mesh	-	100.0	-	100.0	-		-	
-4+6 "	12.0	88.0	1.3	98.7	-	100.0	-	100.0
-6+8 "	12.2	75.8	8.0	90.7	0.1	99.9	0.1	99.9
-8+10 "	17.9	57.9	15.7	75.0	2.2	97.7	1.7	98.2
-10+14 "	12.2	45.7	12.0	63.0	10.3	87.4	10.6	87.6
-14+20 "	10.0	35.7	10.9	52.1	13.5	73.9	15.2	72.4
-20+28 "	7.1	28.6	8.2	43.9	10.8	63.1	11.7	60.7
-28+35 "	6.1	22.5	7.7	36.2	9.9	53.2	10.4	50.3
-35+48 "	4.8	17.7	6.4	29.8	8.5	44.7	8.4	41.9
-48+65 "	4.4	13.3	6.3	23.5	8.8	35.9	8.1	33.8
-65 "	13.3		23.5		35.9		33.8	
Total	100.0		100.0		100.0		100.0	
Speed, rpm	780		1200		780		1200	
Screen, mesh	4		4		8		8	

Gyratory Crusher (Preliminary)

A long-shaft, suspended-spindle, gyratory crusher was used and produced a product with a similar size distribution to that produced by the Hazemag impact crusher. The nature of this crusher is such that most of the crushing action takes place at the bottom of the mantle against the concave, and some difficulty was experienced due to a tendency for the relatively soft clinoptilolite to compress and build up at this point.

As in the preliminary testing with the Hazemag crusher, the new feed to the gyratory crusher went through the jaw and Symons cone crushers. A 4 mesh vibrating screen was placed in front of the gyratory crusher, in closed circuit, so that the feed to the crusher contained little or no -4 mesh material. The crusher discharge returned directly to the screen.

A typical screen test on the -4 mesh product was as follows:

TABLE 3

Results of Preliminary Gyratory Crusher Test

Mesh Size	Weight %	% Pass
+6 mesh	6.7	93.3
-6 +8 "	13.9	79.4
-8 +10 "	13.3	66.1
-10+14 "	9.0	57.1
-14+20 "	8.4	48.7
-20+28 "	6.6	42.1
-28+35 "	6.3	35.8
-35+48 "	5.7	30.1
-48+65 "	6.0	24.1
-65 "	24.1	-
Total	100.0	-

Because of the difficulty experienced with material compacting in this crusher, and because of the relative ease by which the variables effecting the degree of comminution could be altered in the

Hazemag impact crusher it was decided not to use the gyratory crusher for the initial mill run on the 5 ton lot of ore.

OPERATION OF MILL RUN

The installation of the equipment at the Mines Branch was such that a continuous mill run was not possible, so the treatment of the 5 tons of clinoptilolite will be discussed under the appropriate sub-headings.

Initial Crushing

The entire shipment of clinoptilolite was fed into a jaw crusher set at 2 in., thence to a Symons cone crusher set at $\frac{1}{2}$ in., and finally into a Hazemag impact crusher operating at 1200 rpm with the maximum gap setting between the rotor bars and the striker plate.

A 5 mesh vibrating screen, later changed to a 4 mesh screen to decrease the circulating load, was placed in closed circuit with the crushers. The oversize from the screen was returned to the crushing circuit.

Screen tests, which were done on samples taken from several parts of the circuit, are shown in the following table.

TABLE 4

Results of Crushing Circuit Screen Tests

Mesh Size	Symons Crusher Discharge		Hazemag Feed		Hazemag Discharge		Screen Oversize		Screen Undersize	
	Weight %	% Pass	Weight %	% Pass	Weight %	% Pass	Weight %	% Pass	Weight %	% Pass
+1/2 in.	9.4	90.6	-	100.0	-	100.0	-	100.0	-	-
-1/2+3/8 "	25.3	65.3	3.9	96.1	5.2	94.8	2.8	97.2	-	-
-3/8 in.+3 mesh	24.3	41.0	31.4	64.7	28.9	65.9	30.1	67.1	-	-
-3 +4 mesh	11.4	29.6	30.5	34.2	29.2	36.7	33.9	33.2	-	100.0
-4 +6 "	8.2	21.4	19.2	15.0	17.3	19.4	23.5	9.7	4.1	95.9
-6 +8 "	4.7	16.7	5.7	9.3	6.3	13.1	6.9	2.8	16.1	79.8
-8 +10 "	4.0	12.7	1.9	7.4	2.6	10.5	1.5	1.3	15.4	64.4
-10 +14 "	2.7	10.0	1.1	6.3	1.3	9.2	0.4	0.9	9.7	54.7
-14 +20 "	2.2	7.8	0.8	5.5	1.0	8.2	0.2	0.7	8.5	46.2
-20 +28 "	1.6	6.2	0.6	4.9	0.7	7.5	0.1	0.6	6.1	40.1
-28 +35 "	1.4	4.8	0.6	4.3	0.6	6.9	0.1	0.5	5.9	34.2
-35 +48 "	1.0	3.8	0.6	3.7	0.5	6.4	0.1	0.4	4.8	29.4
-48 +65 "	0.8	3.0	0.6	3.1	0.5	5.9	0.1	0.3	5.4	24.0
-65 "	3.0		3.1		5.9		0.3		24.0	
Total	100.0	-	100.0	-	100.0	-	100.0	-	100.0	-

Screening and Grinding

The second stage of the operation involved the screening of the -4 mesh undersize on a 14 mesh vibrating screen. The -14 mesh material was retained for the final screening operation. The +14 mesh fraction was fed at approximately 800 lb/hr to a ball mill with a peripheral discharge near the end of the ball mill, which was in closed circuit with the above mentioned vibrating screen. The ball charge in the mill was varied between 300 lb and 500 lb. Screen tests on the mill discharge showed the effect of increasing the ball load.

TABLE 5

Results of Increasing the Ball Load

Mesh Size	300 lb Load		400 lb Load		500 lb Load	
	Weight %	% Pass	Weight %	% Pass	Weight %	% Pass
+14 mesh	22.0	78.0	27.0	73.0	30.9	69.1
-14+65 "	55.7	22.3	54.8	18.2	43.9	25.2
-65 "	22.3	-	18.2	-	25.2	-
Total	100.0	-	100.0	-	100.0	-

A 400 lb ball charge was maintained during the grinding operation. Figures showing a screen analysis of the feed to the mill would be meaningless since there was no way to adequately mix the screen oversize returns with the new feed. However, a sample of the ball mill discharge was taken at regular intervals during the grinding period and a screen test on this sample was as follows:

TABLE 6

Screen Test on Ball Mill Discharge

Mesh Size	Weight %	% Pass
+3 mesh	-	100.0
-3 +4 "	0.9	99.1
-4 +6 "	1.0	98.1
-6 +8 "	3.5	94.6
-8 +10 "	10.1	84.5
-10 +14 "	11.4	73.1
-14 +20 "	16.3	56.8
-20 +28 "	11.3	45.5
-28 +35 "	9.3	36.2
-35 +48 "	7.0	29.2
-48 +65 "	6.6	22.6
-65 "	22.6	-
Total	100.0	-

Final Screening

At this point the entire shipment had been reduced to -14 mesh and it was necessary now to eliminate by screening the -65 mesh fines.

Three types of vibrating screens were used, a Hum-mer vibrating screen, a Sweco separator, and a Rotex oscillating screen. Each screen was fitted with a 50-mesh wire cloth which has an opening approximately equivalent to a nominal 65 mesh Tyler screen. There were only slight differences in the results of the +65 mesh material delivered from each screen.

All of the screening was done dry, but it was recognized that wet screening should most certainly reduce the percentage of -65 mesh fines contained in the finished product.

Samples were cut at regular intervals from the undersize and the oversize of each screen. The following table shows the results of screen tests on these samples.

TABLE 7

Results of Screen Tests

Mesh Size	Hum-mer		Sweco		Rotex	
	+65 Mesh Fraction		+65 Mesh Fraction		+65 Mesh Fraction	
	Weight %	% Pass	Weight %	% Pass	Weight %	% Pass
+10 mesh	-	100.0	-	100.0	-	100.0
-10+14 "	2.6	97.4	0.7	99.3	0.6	99.4
-14+20 "	25.7	71.7	15.7	83.6	14.8	84.6
-20+28 "	22.5	49.2	24.1	59.5	24.5	60.1
-28+35 "	18.5	30.7	23.1	36.4	23.7	36.4
-35+48 "	14.3	16.4	17.7	18.7	17.8	18.6
-48+65 "	11.8	4.6	14.1	4.6	14.4	4.2
-65 "	4.6	-	4.6	-	4.2	-
Total	100.0	-	100.0	-	100.0	-
	-65 Mesh Fraction		-65 Mesh Fraction		-65 Mesh Fraction	
+48 mesh	-	100.0	-	100.0	-	100.0
-48+65 "	4.0	96.0	4.6	95.4	5.5	94.5
-65 "	96.0	-	95.4	-	94.5	-
Total	100.0	-	100.0	-	100.0	-

The +65 mesh and the -65 mesh fractions were placed in steel drums and shipped to Chalk River. A summary of the material balance from the final screening operation may be seen in the following table.

TABLE 8

Weight of Material

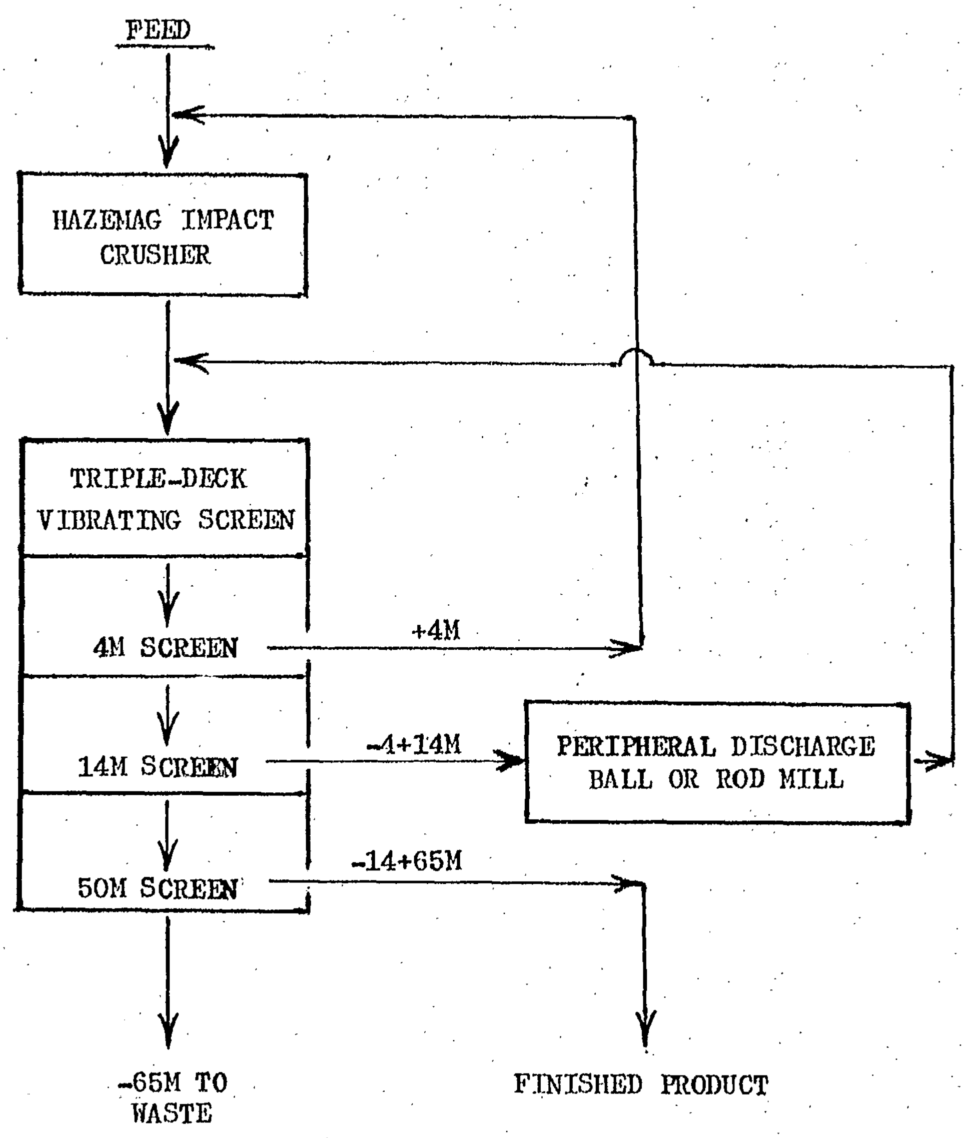
Mesh Size	Hum-mer Screen Weight lb	Sweco Screen Weight lb	Rotex Screen Weight lb	Total Weight lb
+65 mesh	2912	1498	790	5200
-65 "	2036	1089	394	3519
Total	4948	2587	1184	8719
Recovery %	58.8	57.9	66.7	59.6

It was estimated that dust losses were approximately 10% while other losses were set at 3% of the original shipment. Thus, the overall recovery of the -14+65 mesh finished product, based on the original shipment of 5 tons was 52.0%.

CONCLUSIONS

The crushing circuit in the Mines Branch mill is such that it is necessary to crush in the jaw crusher followed by the Symons cone crusher in order to use the Hazemag impact crusher and these two pieces of equipment could not be conveniently by-passed. However, in designing a plant, the Hazemag crusher could be used as the sole primary crusher and is capable of being fed lumps of material, the size of which are limited only by the size of the feed chute and the crushing chamber.

The following flowsheet is designed to meet the requirements of the proposed crushing and screening operation to produce a -14+65 mesh product.



Note: The 50 mesh screen used was almost equivalent to the Tyler 65 mesh screen used in all screen tests.