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CONSERVATION

NEW CONCEPT IN GRINDING FOR ENERGY EFFICIENCY

Final Report

By
V. K. Karra

February 1984

Work Performed Under Contract No. FC07-83ID12439

Rexnord, Inc.
Milwaukee, Wisconsin

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NEW CONCEPT
IN GRINDING FOR
ENERGY EFFICIENCY

FINAL REPORT

FEBRUARY 1984

PREPARED BY

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PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
UNDER COOPERATIVE AGREEMENT
NO. DE-FC07-83ID12439

NEW CONCEPT IN GRINDING FOR ENERGY EFFICIENCY

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Process Machinery Division
Rexnord Inc.

Executive Summary

The objective of the Department of Energy/Rexnord Inc., Cooperative Agreement was to assess the potential energy savings of a laboratory-scale, conveyor-belt-type autogenous (new-concept) mill and compare its performance to a 5.5-ft diameter conventional autogenous mill. The project included provisions for the design, construction, and field testing of a pilot-scale, new-concept mill and technology transfer activities.

Comparative tests with the laboratory-scale, new-concept and conventional mills, using taconite ore, revealed the new-concept mill as inefficient in terms of process and mechanical energy requirements. Since no solutions were readily identified, Rexnord Inc. requested termination of the Cooperative Agreement at a total cost of only 15% of the project budget. However, Rexnord Inc. remains active in the field of comminution research with the objective of improving product performance, including this Rexnord Inc. patented new-concept mill.

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INTRODUCTION

According to the report, "Comminution and Energy Consumption," by the National Materials Advisory Board (NMAB),¹ United States size reduction operations consume about 32 billion kWh of electrical energy per year. While one would like to think this is due to extensive use of the comminution process, it is well known that a substantial amount of the consumed energy relates to the energy inefficiency of crushing and grinding devices. Most particularly, tumbling mills are notoriously inefficient. As stated in the NMAB report, an energy consumption decrease of only 10% in comminution would save the United States about \$160 million for imported oil at current prices. With such an enormous energy-savings potential, the main area for improvement by equipment manufacturers is in energy-efficient comminution device designs, particularly the grinding mills. Cost consciousness of the industry resulted in the popularity of autogenous milling and single-stage grinding using giant-sized mills; more recently, an angular-spiral lining of rounded-square appearance has been cited^{2,3} as reducing the cost of conventional tumbling mill operations. However, these design developments have been to basic drum-type mills.

Since 1979, Rexnord Inc. (Rexnord), has seriously investigated the concept of a new autogenous-milling device based on well-established drum-type tumbling mill design principles. Requirements derived from capital and operating cost economics were the basis for the criteria used in these investigations. The design of the new-concept mill, which diverges from a drum-type configuration in order to maximize the abrasion mechanism of grinding, was believed to provide a substantial potential for fulfilling these criteria and preliminary testing supported the projected energy-savings potential.

A Rexnord proposal, submitted in response to a Department of Energy (DOE) solicitation, resulted in a cost sharing Cooperative Agreement between DOE and Rexnord (DOE: \$250,000; Rexnord: \$127,591; total budget: \$355,591). The contract, signed in April 1983, included six tasks:

1. Review of prior work
2. Laboratory-scale testing
3. Development and installation of a pilot-scale, new-concept mill
4. Field testing of the pilot-scale, new-concept autogenous mill
5. Preparation of equipment specifications, economic analyses, and the organization of technology transfer activities
6. Project management and reporting.

As the project evolved, the new-concept, autogenous mill was discovered as substantially inefficient in mechanical and process energy consumption when compared with the performance of a conventional drum-type autogenous mill. Thus, the Cooperative Agreement project was terminated; early termination resulted in a cost of only 15% of the planned Cooperative Agreement project budget.

This report presents results of the work conducted on the project. Specifically, it covers work performed under Tasks 1 and 2, the comparative performance of a 5 ft x 19 in. new-concept grinding mill relative to a 5.5 ft x 22 in. conventional drum-type grinding mill.

DEFINITION OF TERMS

In this report, the term "performance comparison" refers to the comparison of -325 mesh mill product discharged per unit of energy consumed when the mills are operated autogenously in open circuit with the same feed material. During the work, surface area generation was considered as the basis of comparison, but when products are ground as fine as -325 mesh, the fine material contains essentially all of the surface area produced. More importantly, the -325 mesh production criteria are more easily understood by operations personnel who use the quantity of -325 mesh taconite as the measurement of production in the field. Thus, the decision was made to use the -325 mesh material production criteria.

Critical speed is the theoretical speed at which the centrifugal force on a particle in contact with the mill shell at the apex equals the force on it due to gravity:

$$\text{Critical speed} = 76.63 / \sqrt{D}$$

where

D = diameter of mill inside shell liner.

Mill filling is the volume occupied by the rock mass (called burden or hold-up) in the mill, expressed as a percentage of the total internal volume of the mill.

Machine power requirements are defined in terms of total and net power. Total power is as supplied by the distribution system less the motor and gear reducer losses to facilitate comparative energy consumption analyses. Net power excludes motor, gear reducer, and empty mill rotational losses to facilitate comparative process efficiency analyses. Energy consumption computations are derived from total and net power measurements during steady-state operation (burden is a constant or feed rate is equal to discharge rate).

APPARATUS AND METHODS

Conventional Mill

Figure 1 is a photograph of the 5.5 ft-diameter by 22 in.-wide pilot-scale, drum-type grinding mill; it has 4 in.-high rectangular lifters and a critical speed of 32.68 rpm. The discharge arrangement is of grate-peripheral type, with a 10% open grate area and 0.5 in. slots. The mill speed (71.7% of critical) and mill filling (35%) conditions used in the reference test are very close to optimal autogenous milling conditions in this 5.5 ft-pilot mill.

New-Concept Mill

Figure 2 is a photograph of the laboratory-scale, new-concept mill and Figure 3 is its cross-sectional schematic. The objective in the design of the new-concept mill, which features an endless conveyor belt with flexible sidewalls, was to maintain, on the surface of the belt, counter-moving layers of rock such that abrasion is the chief mechanism of grinding. New-concept mill operating variables are stated in terms of the original design values as developed from the conventional autogenous mill under the above stated conditions. The new-concept device is covered by several patents, either granted¹ or pending.

Ore

Taconite ore, from the central portion of the Mesabi Range of Minnesota, was used for all tests conducted. Published literature describes this ore as a massive, wavy- and even-bedded taconite, from a granular chert-magnetite-silicate iron formation, having a Bond Work Index of 14.7.

Data Acquisition

The conventional autogenous mill total power and speed measurements were derived from transducers on the mill shaft, and burden was derived from load cells on the mill support structure. These data were processed,

and digitally displayed on a central control panel. The total power required by the new-concept mill was derived by subtracting motor and transmission losses from the distribution system supplied power, as measured by a continuous recording wattmeter, through the use of published motor and transmission specifications.

Feed Rate

Both mills were tested in an open-circuit, steady-state configuration, where steady-state was inferred from a stabilized total power condition. In the case of the conventional mill, burden weight was also used to confirm the steady-state conditions. During the tests, mill-feed consisted of -12 in. material with a size distribution of 30% of +6 in., 35% of -6 to +3 in., and 35% of -3 in. material fractions; such a procedure is standard practice in conducting autogenous-milling tests at the Rexnord Mineral Research and Test Center facility.

Sample Analysis

Mill discharge samples were collected under steady-state operating conditions and the entire mill burden, following a run, was used for hold-up determination and particle size analysis. Sieve analyses were performed in conformance with Rexnord's standard procedure, using Tyler standard sieves.

Laboratory Tests and Results

Conventional Mill

The autogenous milling tests were conducted at 71.7% of critical speed and 35% filling. Figure 4 shows how the steady-state feed rate of 720 lbs/h was achieved. Table 1 contains the relevant steady-state performance data, and Figure 5 shows the graphical representation of the sieve analyses in the cumulative percent passing mode. At 720 lbs/h (full capacity), the mill produced an open-circuit discharge containing 41.98%

(weighted average) of -325 mesh product and required 11.23 total (8.03 net) hp. These data served as the basis on which the new-concept mill was judged.

New Concept Mill

Five tests of the new-concept mill are included in this report. The results, as discussed below, are summarized along with the test conditions and performance comparisons in Table 7 for reference purposes.

Tests 1 and 2 of the new-concept mill were performed at the original design conditions; test 1 was initiated with rubber lifters cold-vulcanized to the continuous belt. Figures 6a and 6b show the total power and feed rate during steady-state attainment in tests 1 and 2. If the new-concept mill would have provided a capacity proportional to the conventional mill (720 x 19/22), it would have been approximately 620 lbs/h. The test 1 feed rate was initialized at 660 lbs/h and decreased gradually to the resulting steady-state condition of 420 lbs/h. The 2 in.-high lifters remained intact for a substantial portion of the 6-h 20-min. test; however, at the end of the test, mill inspection showed that more than 2/3 of the lifters either separated from the belt or became less effective due to partial tearing. All the lifters, excepting their thin bases, had become detached during the first hour of the test 2, 8 h operational period. Tables 2 and 3 show performance data for the two tests, and Figures 7 and 8 show graphical representations of the sieve analysis data. At the steady-state capacity of 420 lbs/h, tests 1 and 2 required 16.08 total (11.86 net) and 16.88 total (11.67 net) hp and produced 55.78% and 56.07% (weighted average) of -325 mesh product in their discharge, respectively.

Test 2 provided an assessment of pre-steady-state feed rate strategy and lifter effects on mill capacity. Pre-steady-state feed rate strategy and lifter effects were minimal, as demonstrated in the test 1 and 2 data above; however, stabilization time was shown to be reduced by abandoning the uniform feed rate approach. Thus, additional tests were started with an initial charge of seasoned burden material.

Burden analyses in the conventional and new-concept mill tests 1 and 2 are nearly the same when analyzed as percentages of +6 in., -6 to +3 in., and -3 in. fractions. However, as evident in Figures 7 and 8, top-size control in the new-concept mill discharge was a problem; this was due to the positioning of the adjustable discharge gate at the feed end such as to clear the original 2 in.-high lifters. Occasionally one or two 0.75- to 1.5-in. pieces of rock were contained in the mill discharge, resulting in a rightward parallel shift of the sieve-size analysis. However, this would not be a problem in a lifterless design with a smaller discharge gate opening.

Tests with an ordinary conveyor belt indicated that the inclination of the new concept mill could be reduced to 80% of the original design value, and still maintain counter-moving layers of rock. As a result, tests 3 and 4 were conducted at an angle of 81.4% of the original inclination, an angle that was obtained through modification of the mill structure within the test building.

Figures 9a and 9b show the total power, initial seasoned burden, and feed rate during steady state attainment in tests 3 and 4. While test 3 was conducted at the original mill speed, test 4 included a higher (148.5% of the design value) mill speed. In both cases, the final steady-state feed rate was 300 lbs/h. Tables 4 and 5 show the performance data for the two tests, and Figures 10 and 11 show graphical representations of the sieve analysis data. In test 3, 16.62 total (11.41 net) hp was required to provide a mill discharge containing 61.70% (weighted average) of -325 mesh product. In test 4, 16.62 total (10.43 net) hp was required to provide 42.45% (weighted average) of -325 mesh product in the discharge.

Prior to the contract with DOE, a test of the new concept mill was conducted at 128.6% of the original design inclination; these data are included in this report for completeness. Figure 12 shows total power during attainment of steady-state operation at a uniform feed rate, Table 6 contains the performance data, and Figure 13 shows the graphical representation of the sieve analyses. At the steady-state capacity of

300 lbs/h, 9.65 total (4.44 net) hp was required to produce 37.97% (weighted average) of -325 mesh product in the mill discharge.

Discussion

Early comparative tests of the conventional, autogenous 5.5-ft mill and the new-concept mill demonstrated the energy efficiency of the new-concept mill. Unfortunately, this efficiency was revealed as the result of a calibration error in the newly installed conventional autogeneous pilot mill at Rexnord. The vendor corrected this error upon Rexnord's discovery of the problem and all data in this report reflects the necessary data corrections.

Table 7 shows the comparative energy inefficiency of the new-concept mill over a range of mill speeds and inclinations. In each case, both the mechanical and process energy requirements of the new-concept mill were higher than the conventional mill and the capacity was lower than calculated from the conventional mill. Mechanical loss in the new-concept mill is understandably higher than the conventional mill because of increased roller bearing and belt losses, but the process inefficiency is more complex. Two salient possibilities exist: (1) The new-concept mill relies entirely on cascading action whereas the conventional mill combines cascading and cataracting actions (2) Interaction of the material in the new-concept mill takes place on the elastic belt surface whereas the interaction takes place on inelastic steel in the conventional mill.

Due to the large difference (~ double) in comparative energy requirements and the lack of readily identifiable solutions, a decision was made to proceed slowly in developing the new-concept mill. Since this decision inhibited fulfillment of the contractual obligations with DOE, Rexnord requested contract termination to release obligated funding, by both parties, to more promising projects. Rexnord remains active in the field of comminution research and dedicated to the improvement of process efficiency.

Conclusion

The new-concept autogenous-mill, based on its current design and performance as compared to conventional drum-type autogenous mill is inefficient both in its mechanical and process energy requirements.

Acknowledgments

The project leader sincerely acknowledges the staff of the Mineral Research and Test Center, Rexnord Inc., for their timely and efficient test work, and the Department of Energy for their share of the costs involved.

References

1. "Comminution and Energy Consumption," National Materials Advisory Board, NMAB-364, National Academy Press, Washington, D.C., 1981.
2. Korpi, P.A., and Dopson, G.W., "Angular Sprial Lining Systems in Wet Grinding Grate Discharge Ball Mills," paper presented at the 1979 Annual AIME Meeting, New Orleans, Louisiana, February 18-22, 1979.
3. "Semi-Autogenous Grinding: New KVS Technology Means Even Greater Efficiency," Engineering and Mining Journal, pp. 44-45, November 1980.
4. U.S. Patent No. 4,384,684.

APPENDIX

Fig. 1 Photograph showing the 5.5 ft. x 22 in. conventional grinding mill.

Fig. 2 Photograph showing the 5 ft. x 19 in. new concept grinding mill.

Fig. 3 A schematic cross-section of the new concept grinding mill.

CONVENTIONAL MILL

Fig. 4 Total power, burden, feed, and feed rate during attainment of steady-state operation of the conventional mill.

Table 1

Steady-State Open Circuit Performance of the 5.5 ft x 22 in.
Conventional Autogenous Mill: Reference

Mill Speed: 71.7% of critical
Grate Openings: 0.5"
Grate Open Area: 10%

Feed Rate: 720 lbs/hr Mill Hold-Up: 1,995 lbs
Mill Filling: 34.4% by Volume @ 130 lbs/cft Bulk Density
Percent Solids: 62% Power: 8.03 hp (net)
11.23 hp (total)

Product Analysis

Sieve Opening (in. or mesh)	Cumulative Percent Passing			
	Sample 1	Sample 2	Sample 3	Sample 4
0.742"	100.0	100.0	100.0	100.0
0.525"	97.6	99.2	97.0	98.4
0.371"	93.7	94.9	94.5	93.4
3	89.1	91.1	90.0	90.6
4	86.4	89.2	87.9	88.6
6	84.5	87.9	86.3	87.3
8	82.9	86.8	85.0	85.8
10	81.3	85.4	83.7	84.0
14	79.5	83.9	82.2	82.3
20	77.4	81.9	80.5	80.3
28	75.1	79.7	78.6	78.1
35	72.2	77.3	76.4	75.6
48	68.7	73.7	73.0	72.1
65	64.4	69.4	69.0	68.1
100	58.7	63.7	63.3	62.6
150	52.7	57.6	57.1	56.7
200	46.4	50.8	50.3	50.1
270	42.5	46.5	46.0	45.7
325	39.4	43.3	43.1	42.4

Mill Burden Analysis

Sieve Opening (inches)	Cumulative Passing (percent)
8.00	100.0
6.00	89.5
4.00	63.7
3.00	44.2
2.10	19.4
1.48	9.6
1.05	3.4

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INTERNATIONAL
STANDARD

WEIGHT PERCENTAGE, CUMULATIVE PASSING

U.S.A. No.

TYLER MESH

Rexnord
Process
Machinery Division

MACHINE: (Type, Size, Setting, Speed, HP, Liners)

5'5" X 22" CONVENTIONAL AUTOGENOUS MILL

CIRCUIT: (Feed Rate & Consist, Surge or Controlled, Thru-Put, Ratio of Reduction, Product Spec.)

OPEN CIRCUIT, 0.5 IN. SLOTS (10% OPEN AREA) IN GRATE,
72% CRITICAL SPEED

MATERIAL: (Type, Location, WI, Silica Equivalent)

TACONITE

720 LBS/HR, 62% SOLIDS, 1995 LBS. HOLD-UP, 8.03 HP NET

ISSUE
DATE

MAY 1983

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APPLICATION DATA

SHEET NO.

FIGURE 5

NEW CONCEPT MILL

Fig. 6a & 6b Total power and feed rate during attainment of steady-state operation of the new-concept mill tests 1 & 2.

Table 2

Steady-State Open Circuit Performance of the 5 ft x 19 in.
New Concept Autogenous Mill: Test #1

Mill Speed:	Original	Mill Inclination:	Original
Feed Rate:	420 lbs/hr	Mill Hold-Up:	1,438 lbs
Percent Solids:	60%	Power:	11.86 hp (net)
			16.08 hp (total)

Product Analyses

Sieve Opening (in. or mesh)	Cumulative Percent Passing			
	Sample 1	Sample 2	Sample 3	Sample 4
1.48"	100.0		100.0	100.0
1.05"	96.6		91.5	86.4
0.742"	89.7	100.0	85.3	84.8
0.525"	88.7	98.5	79.9	83.0
0.371"	86.2	95.9	76.6	81.4
3	83.9	94.0	74.9	79.0
4	82.0	92.0	73.3	76.9
6	79.4	89.5	71.0	74.7
8	77.0	87.1	68.8	72.8
10	74.7	85.0	66.6	71.1
14	73.3	84.0	65.5	70.2
20	72.6	83.2	65.0	69.5
28	72.1	82.7	64.5	69.0
35	71.6	82.1	64.1	68.6
48	71.0	81.2	63.5	67.8
65	69.9	79.9	62.6	66.9
100	68.2	78.1	61.1	65.1
150	65.7	75.3	58.9	62.6
200	61.5	71.1	55.2	58.5
270	58.0	67.6	52.3	55.3
325	55.5	64.6	50.2	53.2

Mill Burden Analysis

Sieve Opening (inches)	Cumulative Passing (percent)
8.00	100.0
6.00	86.3
4.00	62.0
3.00	42.6
2.10	18.8
1.48	7.3
1.05	1.5

Table 3

Steady-State Open Circuit Performance of the 5 ft x 19 in.
New Concept Autogenous Mill: Test #2

Mill Speed:	Original	Mill Inclination:	Original
Feed Rate:	420 lbs/hr	Mill Hold-Up:	1,534 lbs
Percent Solids:	60%	Power:	11.67 hp (net) 16.88 hp (total)

Product Analyses

Sieve Opening (in. or mesh)	Cumulative Percent Passing			
	Sample 1	Sample 2	Sample 3	Sample 4
1.48"			100.0	
1.05"	100.0	100.0	82.6	100.0
0.742"	95.7	96.2	78.2	91.8
0.525"	92.8	95.3	78.2	90.7
0.371"	88.3	90.7	74.0	89.8
3	85.6	89.1	71.3	88.5
4	83.3	87.3	69.6	87.2
6	81.9	85.6	68.5	85.7
8	80.3	84.2	67.3	84.5
10	78.6	82.9	65.8	83.0
14	77.6	82.0	64.9	82.1
20	76.9	81.3	64.2	81.5
28	76.2	80.7	63.7	80.8
35	75.6	80.0	63.2	80.1
48	74.6	79.1	62.4	79.2
65	73.3	77.8	61.4	77.9
100	71.1	75.6	59.7	75.9
150	67.9	72.2	57.2	72.8
200	63.5	67.6	53.5	68.2
270	59.8	63.6	50.3	64.2
325	56.9	60.2	47.6	61.4

Mill Burden Analysis

Sieve Opening (inches)	Cumulative Passing (percent)
8.00	100.0
6.00	90.6
4.00	65.7
3.00	47.5
2.10	23.0
1.48	10.1
1.05	3.4

INTERNATIONAL
STANDARD21
WEIGHT PERCENTAGE, CUMULATIVE PASSING

U.S.A. No.

TYLER MESH

Rexnord
Process
Machinery Division

MACHINE: (Type, Size, Setting, Speed, HP, Liners)

5' X 19" NEW CONCEPT AUTOGENOUS MILL

CIRCUIT: (Feed Rate & Consist, Surge or Controlled, Thru-Put, Ratio of Reduction, Product Spec.)

OPEN CIRCUIT, STD. INCLINATION, STD. SPEED

TEST #1

MATERIAL: (Type, Location, Wt, Silica Equivalent)

TACONITE

420 LBS/HR, 60% SOLIDS, 1438 LBS. HOLD-UP, 11.86 HP NET

ISSUE DATE MAY 1983

SUPERCEDES

REV.

APPLICATION DATA

SHEET NO.
FIGURE 7

INTERNATIONAL
STANDARD

WEIGHT PERCENTAGE, CUMULATIVE PASSING

U.S.A. No.

TYLER MESH

Rexnord
Process
Machinery Division

MACHINE: (Type, Size, Setting, Speed, HP, Liners)

5' X 19" NEW CONCEPT AUTOGENOUS MILL

CIRCUIT: (Feed Rate & Consist, Surge or Controlled, Thru-Put, Ratio of Reduction, Product Spec.)

OPEN CIRCUIT, STD. INCLINATION, STD. SPEED
TEST #2

MATERIAL: (Type, Location, Wt, Silica Equivalent)

TACONITE
420 LBS/HR, 60% SOLIDS, 1534 LBS. HOLD-UP, 11.67 HP NET

ISSUE DATE MAY 1983

SUPERCEDES

REV.

APPLICATION DATA

SHEET NO.
FIGURE 8

NEW CONCEPT MILL

Fig. 9a & 9b Total power, initial seasoned burden, and feed rate during attainment of steady-state operation of the new-concept mill tests 3 & 4.

Table 4

Steady-State Open Circuit Performance of the 5 ft x 19 in.
New Concept Autogenous Mill: Test #3.

Mill Speed:	Original	Mill Inclination:	81.4% of Original
Feed Rate:	300 lbs/hr	Mill Hold-Up:	1,597 lbs
Percent Solids:	60%	Power:	11.41 hp (net)
			16.62 hp (total)

Product Analyses

Sieve Opening (in. or mesh)	Cumulative Percent Passing	
	Sample 1	Sample 2
0.742"		100.0
0.525"	100.0	95.2
0.371"	97.7	91.6
3	94.5	89.1
4	92.9	87.3
6	91.9	86.1
8	90.7	85.1
10	89.4	84.1
14	88.2	83.0
20	87.2	82.0
28	85.9	81.0
35	84.6	79.7
48	83.1	78.5
65	81.4	77.0
100	78.8	74.7
150	75.6	71.1
200	70.8	65.1
270	67.0	61.3
325	63.7	59.7

Table 5

Steady-State Open Circuit Performance of the 5 ft x 19 in.
New Concept Autogenous Mill: Test #4.

Mill Speed: 148.5% of Original	Mill Inclination: 81.4% of Original
Feed Rate: 300 lbs/hr	Mill Hold-Up 774 lbs
Percent Solids: 60%	Power: 10.43 hp (net)
	16.62 hp (total)

Product Analyses

<u>Sieve Opening</u> <u>(in. or mesh)</u>	<u>Cumulative Percent Passing</u>	
	<u>Sample 1</u>	<u>Sample 2</u>
1.48"	100.0	100.0
1.05"	78.7	82.3
0.742"	75.2	77.6
0.525"	72.6	77.6
0.371"	70.0	76.3
3	69.6	75.7
4	68.9	74.6
6	68.0	73.7
8	66.7	72.1
10	64.1	68.4
14	62.2	65.7
20	61.1	64.1
28	60.2	62.8
35	59.3	61.5
48	58.3	60.0
65	57.0	58.2
100	55.2	55.5
150	52.4	52.0
200	48.5	47.1
270	45.6	43.1
325	43.1	41.8

Mill Burden Analysis

<u>Sieve Opening</u> <u>(inches)</u>	<u>Cumulative Passing</u> <u>(percent)</u>
8.00	100.0
6.00	93.4
4.00	70.7
3.00	53.9
2.10	24.9
1.48	11.4
1.05	2.5

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INTERNATIONAL
STANDARD

WEIGHT PERCENTAGE, CUMULATIVE PASSING

WEIGHT PERCENTAGE, CUMULATIVE RETAINED

U.S.A. No.
TYLER MESH
Rexnord

 Process
 Machinery Division

MACHINE: (Type, Size, Setting, Speed, HP, Liners)

5'X19" NEW CONCEPT AUTOGENOUS MILL

CIRCU T: (Feed Rate & Consist, Surge or Controlled, Thru-Put, Ratio of Reduction, Product Spec.)

OPEN CIRCUIT, INCLINATION: 81.4% OF STD., STD. SPEED
TEST 3

MATERIAL: (Type, Location, Wt, Silica Equivalent)

TACONITE 300 LBS./HR.
60% SOLIDS, 1597 LBS. HOLD-UP, 11.41 HP. NETISSUE
DATE JUNE 1983

SUPERCEDES

REV.

APPLICATION DATA

SHEET NO.
FIGURE 10

INTERNATIONAL
STANDARD

WEIGHT PERCENTAGE, CUMULATIVE PASSING

U.S.A. No.

TYLER MESH

Rexnord
Process
Machinery Division

MACHINE: (Type, Size, Setting, Speed, HP, Liners)

5' X 19" NEW CONCEPT AUTOGENOUS MILL

CIRCUIT: (Feed Rate & Consist, Surge or Controlled, Thru-Put, Ratio of Reduction, Product Spec.)

OPEN CIRCUIT, INCLINATION: 81.4% OF STD.,
SPEED: 148.5% OF STD.

TEST 4

MATERIAL: (Type, Location, WI, Silica Equivalent) TACONITE 300 LBS/HR,
6.0% SOLIDS, 774 LBS. HOLD-UP, 0.43 HP. NET

ISSUE JUNE 1983

DATE

SUPERCEDES

REV.

APPLICATION DATA

SHEET NO.
FIGURE II

NEW CONCEPT MILL

Fig. 12 Total power at constant feed rate during attainment of steady-state operation of the new-concept mill test 5.

Table 6

Steady-State Open Circuit Performance of the 5 ft x 19 in.
New Concept Autogenous Mill: Test #5

Mill Speed:	Original	Mill Inclination:	128.6% of Original
Feed Rate:	300 lbs/hr	Mill Hold-Up:	694 lbs
Percent Solids:	60%	Power:	4.44 hp (net)
			9.65 hp (total)

Product Analyses

Sieve Opening (in. or mesh)	Cumulative Percent Passing		
	Sample 1	Sample 2	Sample 3
1.48"	100.0	100.0	100.0
1.05"	90.0	84.8	89.2
0.742"	80.1	79.0	89.2
0.525"	78.4	78.3	84.8
0.371"	75.5	73.5	80.1
3	71.7	70.9	75.8
4	69.7	69.1	73.8
6	67.7	67.4	72.1
8	64.8	65.5	70.1
10	62.2	62.9	67.5
14	60.7	61.3	65.9
20	59.2	60.0	64.4
28	57.9	58.7	62.8
35	56.4	57.2	61.1
48	54.6	55.5	59.2
65	52.6	53.5	56.9
100	49.9	50.7	53.8
150	47.2	47.4	50.3
200	42.6	42.9	45.5
270	39.3	39.9	42.3
325	36.8	37.4	39.7

Mill Burden Analysis

Sieve Opening (inches)	Cumulative Passing (percent)
8.00	100.0
6.00	73.7
4.00	47.0
3.00	31.1
2.10	12.7
1.48	6.1
1.05	3.5

INTERNATIONAL
STANDARD30
WEIGHT PERCENTAGE, CUMULATIVE PASSING

U.S.A. No.

TYLER MESH

Rexnord
Process
Machinery Division

MACHINE: (Type, Size, Setting, Speed, HP, Liners)

5'x19" NEW CONCEPT AUTOGENOUS MILL

CIRCUIT: (Feed Rate & Consist, Surge or Controlled, Thru-Put, Ratio of Reduction, Product Spec.)

OPEN CIRCUIT, INCLINATION: 128.6% OF STD., STD. SPEED
TEST #5

MATERIAL: (Type, Location, Wt, Silica Equivalent)

TACONITE 300 LBS/HR
60% SOLIDS, 694 LBS. HOLD-UP 4.44 HP NETISSUE
DATE JAN 1982

SUPERCEDES

REV.

APPLICATION DATA

SHEET NO.
FIGURE 13

Table 7

Autogenous Grinding: Comparison of Energy Consumption
5.5' x 22" Conventional Mill vs. 5' x 19" New Concept Mill
Basis: Production of -325 mesh material

Test Number	Grinding Conditions			
	Mill Type	Lifters	Speed	Inclination
Ref	Conventional	4" high	71.7% Crit.	-
1	New Concept	2" high	Std	Std
2	New Concept	-	Std	Std
3	New Concept	-	Std	81.4% of Std
4	New Concept	-	148.5% of Std	81.4% of Std
5	New Concept	-	Std	128.6% of Std

Test Number	Capacity (lbs/hr)	-325# in Mill Discharge (%)	Power (hp)	
			Total	Net
Ref	720	41.98	11.23	8.03
1*	420	55.78	16.08	11.86
2	420	56.07	16.88	11.67
3	300	61.70	16.62	11.41
4**	300	42.45	16.62	10.43
5***	300	37.97	9.65	4.44

Test Number	Total hp/stph of -325# product	Net hp/stph of -325# product	Excess Energy Consumption over Conventional (%)	
			Total hp basis	Net hp basis
Ref	74.31	53.13	-	-
1*	137.27	101.25	84.73	90.57
2	143.36	99.11	92.92	86.54
3	179.58	123.28	141.66	132.03
4**	261.01	163.80	251.24	208.30
5***	169.43	77.96	128.00	46.73

* At the end of the test more than 2/3 of the lifters were either gone or became less effective due to partial tearing.

** These data are questionable due to mill malfunction during test; upon disassembly, one of the stub rollers in the upper bend was found to have moved inward and bored a 4 in. dia. hole in the skirt plate.

*** This test was done prior to the DOE contract, using a slightly coarser (40/20/40) feed than the one (30/35/35) employed in the present work.

**** hp/stph = horsepower per short ton of product per hour

90 Corp