PREPARATION OF BISMUTH POWDER

Information Report

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INTRODUCTION

The principal object of this report is to record results of tests made on equipment installed in Room 232 of "T" Building and used to prepare bismuth powder for process operations.

Another object is to establish the most favorable operating conditions for the equipment and to prepare operating instructions therefor.

CONCLUSIONS

Bismuth powder may be prepared rapidly and economically with equipment as installed.

The hammer mill can be operated at a rate of 135 lbs. per hour of bismuth pig.

The ball mill can be operated at a rate of 3.7 lbs. per hour of 140 mesh product; 2.0 lbs. per hour of 200 mesh product, and 5.7 lbs. per hour of 140 + 200 mesh product.

The screening operation on one Ro-Tap shaker can separate material from the ball mill at this rate.

For maximum efficiency in preparing 140 mesh powder the ball mill should be operated with a feed load of 2.0 kg.; ball load 4.0 kg.; grinding time 15 minutes; jar r.p.m. 84.

For maximum efficiency in preparing 200 mesh powder the ball mill should be operated with a feed load of 2.5 kg.; a ball load of 4.5 kg.; grinding time 15 minutes; jar r.p.m. 84.

For maximum efficiency in preparing 140 and 200 mesh powder the ball mill should be operated with a feed load of 2.0 kg.; a ball load of 4.0 kg.; grinding time 15 minutes; jar r.p.m. 84.

Optimum operation of the Ro-Tap shaker is obtained with a screen time of five minutes and a screen load of 1000 grams.

No significant differences were observed in process operations at Unit IV using powder prepared on this equipment and powder prepared at Unit IV.

Description

Apparatus installed in Room 232 is as follows.

1 - Ball Mill, manufactured by Paul O. Abbe Inc., Little Falls, New Jersey, Serial No. 46680, U.S.A. No. 7444, fitted with three porcelain jars 8 1/2" in diameter by 8 1/2" high.

1 - Sieve Shaker, "Ro-Tap", manufactured by W. S. Tyler Company, Cleveland, Ohio, Serial No. 6280, U.S.A. No. 7410.


Sphalerite is purchased in "pigs" having the dimensions shown in Figure 1. These pigs are packed in a wood box, usually 28 pigs to a box, weighing approximately 170 pounds net.

Each pig is broken at the "neck" or groove by means of a hammer, forming four truncated pyramids of metal which are fed to the swing sledge hammer mill for the first reduction.

These metal pyramids or "slugs" are reduced in the hammer mill at the rate of approximately 90 per hour, or 45 seconds per slug. Each slug weighs 1.5 lbs. and, at the rate of 90 slugs per hour, the mill will grind 135 lbs. per hour. At this rate the mill loss is 4.8 per cent consisting of fine dust which sifts out of joints in the mill housing. The mill as received was not provided with gaskets in these joints, but it is believed that tight gaskets at these places would reduce this loss somewhat. However, this material is so finely ground that it passes through the screens and is discarded as waste during separation of the powder, and it may be reported either as mill loss or as waste.

A typical screen analysis of material from this mill is tabulated in Figure 2 and the data are plotted in Figure 3.

Material distribution is shown in Figure 4 for a final product of either 140 mesh or 200 mesh.

It is assumed that a final product of either 140 mesh or of 200 mesh will be required. If both grades of material can be used, these may be separated as final product as indicated in Figure 4.

The product from the hammer mill is screened by 2" deep U.S. Bureau of Standards sieves, using a
Figure 1

Average Weight: 6 Lbs
Figure 2

SCREEN ANALYSIS

<table>
<thead>
<tr>
<th>MESH</th>
<th>% RETAINED</th>
<th>% CUMULATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>On 20</td>
<td>18.8</td>
<td>18.8</td>
</tr>
<tr>
<td>On 60</td>
<td>38.9</td>
<td>57.7</td>
</tr>
<tr>
<td>On 100</td>
<td>16.3</td>
<td>74.0</td>
</tr>
<tr>
<td>On 140</td>
<td>6.9</td>
<td>80.9</td>
</tr>
<tr>
<td>On 200</td>
<td>6.3</td>
<td>87.2</td>
</tr>
<tr>
<td>On 325</td>
<td>6.9</td>
<td>94.1</td>
</tr>
<tr>
<td>Through 325</td>
<td>5.9</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Fig 3

OBSERVED PERFORMANCE
SWING SLEDGE HAMMER MILL
1/4 x 1/4 x 1/4 FEED

[Graph showing observed performance data for a swing sledge hammer mill with a 1/4 x 1/4 x 1/4 feed.]
### Figure 4

**Material Distribution**

<table>
<thead>
<tr>
<th></th>
<th>140 Mesh Product</th>
<th>200 Mesh Product</th>
<th>140+200 Mesh Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material to Hammer Mill</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Hammer Mill Loss</td>
<td>4.8</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Product</td>
<td>6.6</td>
<td>6.0</td>
<td>12.6</td>
</tr>
<tr>
<td>To Ball Mill</td>
<td>70.4</td>
<td>77.0</td>
<td>70.4</td>
</tr>
<tr>
<td>Waste</td>
<td>18.2</td>
<td>12.2</td>
<td>12.2</td>
</tr>
<tr>
<td>Efficiency</td>
<td>77.0</td>
<td>83.0</td>
<td>83.0</td>
</tr>
<tr>
<td>Ball Mill Feed on 20 Mesh</td>
<td>25.4</td>
<td>23.3</td>
<td>25.4</td>
</tr>
<tr>
<td>Ball Mill Feed on 60 Mesh</td>
<td>52.6</td>
<td>48.2</td>
<td>52.6</td>
</tr>
<tr>
<td>Ball Mill Feed on 100 Mesh</td>
<td>22.0</td>
<td>20.2</td>
<td>22.0</td>
</tr>
<tr>
<td>Ball Mill Feed on 140 Mesh</td>
<td></td>
<td>8.3</td>
<td></td>
</tr>
</tbody>
</table>
and a screen time of five minutes. Generally, the sieve stack will consist of two sieves, oversize and product, with the oversize recycled to ball mills for further grinding, the product retained and the material passing the product sieve discarded as waste. By inserting two product sieves in the stack, two grades of product may be separated in one operation.

Tests were made on the ball mill over a wide range of loadings using product from the hammer mill as feed. Data from some of these tests are plotted in Figures 5 through 24.

These data indicate that the maximum quantity of 140 mesh product is obtained with a ball load of 4.0 kg. and a feed load of 2.0 kg. Maximum quantity of 200 mesh product is produced with a ball load of 4.5 kg. and a feed load of 2.5 kg. The data are tabulated in Figure 25.

Figures 26, 27, and 28 are summaries of the performance data and show the overall efficiencies obtained when grinding powders of several different grades.

The data indicate that a screen time of five minutes is adequate when sieves are shaken on the "Ro-Top" shaker. A screen time in excess of this value does not result in improved separation and does contribute to screen wear. A screen load of 1000 grams gives the best separation in the established time and does not cause undue wear while a load in excess of 1000 grams causes rapid sieve wear and screen clogging.

Samples of powder prepared on this equipment were submitted to the Production Research Department for iron analysis. The data are tabulated in Figure 29.

Bismuth powder prepared on this equipment was used in production operations at Unit IV on and after December 6, 1943. While the operations at Unit IV are different from those set up for Unit V, comparison of runs made under similar conditions should indicate significant differences in powder produced at these two locations. The data tabulated in Figure 30 show the scrubbing efficiencies of sample lots of powder from this equipment compared with runs made immediately prior thereto using powder prepared at Unit IV.

Comparison of 53 solutions processed by the Process Group from material using powder prepared at Unit V with 53 solutions from material using powder prepared at Unit IV was made. The data show an average purity of 95.2 per cent for solutions from material using powder prepared by this method and an average purity of 95.6 per cent for solutions from material using the old powder. This variation is within the usual day-to-day operating
Fig 6

Observed Performance
Abbe Ball Mill Grinding
140 Mesh Product

Ball Load - 2.5 Kg.

% Recycle

% Waste

% Product

Feed Load Kg.

0 10 15 20 25 30 35 40
UNCLASSIFIED

BALL LOAD - 40 KG

OBSERVED PERFORMANCE
ABBE BALL MILL GRINDING
140 MESH PRODUCT

% WASTE

% RECYCLE

% PRODUCT

FEED LOAD, KG

-14-

MIL-295
BALL LOAD 4.5 KG

OBSERVED PERFORMANCE
ABBE BALL MILL GRINDING
140 MESH PRODUCT

-15-
Observed Performance
Abbe Ball Mill Grinding
140 mesh product

Feed Load - kg

Ball Load, Kg

0 2.5 3.0 3.5 4.0 4.5

Recycle

Waste

Product
FIG. 15

OBSERVED PERFORMANCE
CEREB BALL MILL GRINDING
140 MESH PRODUCT

UNCLASSIFIED

FEED LOAD - 3.5 KG

90
80
70
60
50
40
30
20
10
0

PERCENT

BALL LOAD, KG

25
30
35
40
45
Fig. 18
OBSERVED PERFORMANCE
ABBE BALL MILL GRINDING
200 MESH PRODUCT

BALL LOAD - 3.0 KG

UNCLASSIFIED

PERCENT

GRAMS

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10

0-10
Ball Load - 5.5 Kg

Observed Performance
ABBE Ball Mill Grinding
200 Mesh Product

% Recycle

% Waste

Grams Product

% Product

Feed Load, Kg

0 10 15 20 30 35 40
Fig. 21

OBSERVED PERFORMANCE
ABBE BALL MILL GRINDING
200 MESH PRODUCT

BALL LOAD - 4.5 kg

PERCENT

0 10 20 30 40

0 x 10-grams

0.00 0.10 0.20 0.30 0.40

0 10 15 20 25 30 35 40

FEED

OBSERVED
Fig. 22
OBSERVED PERFORMANCE
ABBE BALL MILL GRINDING
200 MESH PRODUCT

FEED LOAD - 0.5 KG

BALL LOAD, KG:
0 2.5 3.0 4.5

PERCENT
50 70

WASTE
RECYCLE
PRODUCT
UNCLASSIFIED

Fig. 23

OBSERVED PERFORMANCE
ABBE BALL MILL GRINDING
200 MESH PRODUCT

Feed Load - 1.0 kg

Product

Recycle

Waste

Ball Load - kg

No. 25: 1.0 10 x 10 mesh shales screened

-26-
OBSERVED PERFORMANCE
ABBE BALL MILL GRINDING
200 MESH PRODUCT

UNCLASSIFIED

BALL LOAD, Kg

UNCLASSIFIED

UNCLASSIFIED
### Figure 25

#### BALL MILL PERFORMANCE

<table>
<thead>
<tr>
<th></th>
<th>140 MESH PRODUCT</th>
<th>200 MESH PRODUCT</th>
<th>140-200 MESH PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball Load, Kg.</td>
<td>4.0</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Feed Load, Kg.</td>
<td>2.0</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Product, Grams</td>
<td>284</td>
<td>160</td>
<td>438</td>
</tr>
<tr>
<td>Recycle, Grams</td>
<td>1208</td>
<td>1935</td>
<td>1208</td>
</tr>
<tr>
<td>Waste, Grams</td>
<td>508</td>
<td>355</td>
<td>354</td>
</tr>
<tr>
<td>Efficiency (Prod./Prod.+Waste) %</td>
<td>35.9</td>
<td>31.1</td>
<td>55.3</td>
</tr>
<tr>
<td>Grinding Time, Min.</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>R. P. M. Jar</td>
<td>84</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>Grinds Per Hour</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Product, Kg./Hour</td>
<td>1.7</td>
<td>.9</td>
<td>2.6</td>
</tr>
<tr>
<td>Material</td>
<td>Waste</td>
<td>Product</td>
<td>Waste</td>
</tr>
<tr>
<td>----------------</td>
<td>-------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td>6.9%</td>
<td>10.0%</td>
<td>6.6%</td>
</tr>
<tr>
<td>71.1%</td>
<td></td>
<td></td>
<td>42.5%</td>
</tr>
<tr>
<td>42.5%</td>
<td></td>
<td></td>
<td>71.9%</td>
</tr>
<tr>
<td>71.9%</td>
<td></td>
<td></td>
<td>10.0%</td>
</tr>
<tr>
<td>10.0%</td>
<td></td>
<td></td>
<td>70.4%</td>
</tr>
<tr>
<td>70.4%</td>
<td></td>
<td></td>
<td>18.2%</td>
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<td>18.2%</td>
<td></td>
<td></td>
<td>6.6%</td>
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<td>6.6%</td>
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<td></td>
<td>4.8%</td>
</tr>
<tr>
<td>4.8%</td>
<td></td>
<td></td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Note: The last line 'Prime 26' and 'MIL-295' are also included in the document.
<table>
<thead>
<tr>
<th>Material</th>
<th>Product</th>
<th>Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.9</td>
<td>6.9</td>
<td>6.9</td>
</tr>
<tr>
<td>10.9</td>
<td>4.7</td>
<td>4.9</td>
</tr>
<tr>
<td>9.9</td>
<td>6.0</td>
<td>0.0</td>
</tr>
<tr>
<td>12.2</td>
<td>6.02</td>
<td>0.8</td>
</tr>
<tr>
<td>7.8</td>
<td>4.8</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: The table contains data related to material, product, and waste. The total column represents the sum of the product and waste.
Figure 28

BISMUTH POWDER

140 ± 200 MESH PRODUCT

<table>
<thead>
<tr>
<th></th>
<th>MATERIAL</th>
<th>PRODUCT</th>
<th>WASTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock to Hammer Mill</td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hammer Mill Loss</td>
<td>4.8</td>
<td></td>
<td>4.8%</td>
</tr>
<tr>
<td>Product</td>
<td>12.6</td>
<td>12.6%</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td>12.2</td>
<td></td>
<td>12.2%</td>
</tr>
<tr>
<td>Feed to Ball Mill</td>
<td>70.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>15.4</td>
<td>15.4%</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td>12.5</td>
<td></td>
<td>12.5%</td>
</tr>
<tr>
<td>Recycle to Ball Mill</td>
<td>42.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>28.0</td>
<td>24.7%</td>
</tr>
<tr>
<td>Efficiency % (Prod./Prod.+Waste)</td>
<td>53.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste %</td>
<td>46.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Figure 22

**ANALYSIS OF POLYMER**

<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>P.P.M. IRON</th>
<th>PRECISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>140-A</td>
<td>40</td>
<td>± 5</td>
</tr>
<tr>
<td>140-B</td>
<td>28</td>
<td>± 5</td>
</tr>
<tr>
<td>140-C</td>
<td>28</td>
<td>± 5</td>
</tr>
<tr>
<td>200-A</td>
<td>38</td>
<td>± 5</td>
</tr>
<tr>
<td>200-B</td>
<td>38</td>
<td>± 5</td>
</tr>
<tr>
<td>200-C</td>
<td>34</td>
<td>± 5</td>
</tr>
</tbody>
</table>
### Figure 30

**SCRUBBING EFFICIENCY**

<table>
<thead>
<tr>
<th></th>
<th>140 MESH</th>
<th>200 MESH</th>
<th>140 + 200 MESH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit IV Powder, No. Runs</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Unit IV Powder, Mean Recovery</td>
<td>95.82</td>
<td>98.92</td>
<td></td>
</tr>
<tr>
<td>Unit V Powder, No. Runs</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Unit V Powder, Mean Recovery</td>
<td>95.59</td>
<td>99.59</td>
<td>98.91</td>
</tr>
</tbody>
</table>
variations and indicates satisfactory performance.

These data indicate no significant differences were observed and that powder prepared by this equipment is satisfactory for use as scrub powder in process operations.

Reference: Lab. Note Book, pages 202555-202585