METHOD OF WET-GRINDING IN A ROTARY DRUM

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1 Claim. (Cl. 241—21)

This invention relates to the grinding of ores and other mineral materials as practiced in the mining and cement industries and is concerned more particularly with a novel method of wet-grinding such materials in mill drums as part of a tumbling load which includes non-metallic bodies.

In the grinding of minerals in rotary drums, such as tube mills, it is common practice to employ grinding bodies which are usually of steel or cast iron. In the grinding operation, the wear on the grinding bodies forms a considerable part of the total cost, particularly when hard materials are being ground, and the expenditures for metallic grinding bodies may be at least as great as the cost of the power consumed and is frequently considerably greater.

To reduce the cost of grinding by the use of metallic grinding bodies, it is common to use non-metallic grinding media in the form of pebbles or to practice autogenous grinding, that is, grinding of the material by means of the material itself in the form of large lumps. As grinding bodies formed of pebbles or lumps of the material to be ground are of much lower specific gravity than iron bodies, the use of such non-metallic bodies reduces the capacity of a given mill by from 50% to 70%. To compensate for this reduction in capacity, it has become the practice in recent years to increase the speed of rotation of the mill to a value just below the critical speed or to a super-critical speed exceeding the critical speed by from 20% to 50%. The critical speed refers to the speed of rotation of a mill, at which the centrifugal force required to maintain a grinding body in circular motion at the inner periphery of the mill is equal to the force of gravity and a mathematical expression for such critical speed is

\[ n_c = \frac{78.6}{\sqrt{D}} \]

where \( n_c \) is measured in revolutions per minute and \( D \) is the inside diameter of the mill in feet.

The present invention is based on observations made in grinding cement raw material slurries at speeds just below or above the critical speed of the mill. In experiments, it has been found that an increase in the output of a mill can be obtained, if the quantity of slurry present in the charge occupies a limited proportion of the voids between the grinding bodies and the slurry has a yield value in the range from 300 to 900 dynes/cm\(^2\). The yield value referred to is a measure of the fluidity of the slurry and is a characteristic constant for plastic liquids, of which cement raw material is an example. The yield value of a slurry may be determined by a Stormer viscometer.

In the practice of the invention, a charge of non-metallic grinding bodies and a quantity of slurry sufficient to occupy from 40% to 80% of the voids among the bodies and of a yield value in the range from 300 to 900 dynes/cm\(^2\) are introduced into a rotary drum, such as a tube mill, and the drum is rotated at a speed within the range from just below the critical speed to about 150% of the critical speed. Slurry containing particles below a selected size continually withdrawn from the mill and slurry of a yield value within the specified range is introduced into the mill at a rate to maintain the specified quantity of slurry within the mill. The practice of the invention makes it possible to increase the output of a mill of given size to two or more times the output under normal working conditions so that the output approximates that obtained by the use of iron grinding bodies with the mill operating at a normal speed.

In order to show the advantages of the invention, tests were carried out in a mill 600 mm. in diameter and 720 mm. long. The grinding bodies used were pebbles formed of pieces of limestone which had been both wet and the entire charge occupied 30% of the total volume of the mill. The material ground was limestone slurry, which had been subjected to primary grinding. In one series of tests, the slurry employed had a yield value of 400 dynes/cm\(^2\) as determined by a Stormer viscometer, and the power consumption for grinding, which is a measure of the effectiveness of the grinding and indicative of the mill output, was determined for various slurry charges and varying mill speeds.

In Table I, the slurry charge is specified as the percentage of the voids in the charge of grinding bodies which the slurry occupies.

<table>
<thead>
<tr>
<th>Slurry Charge, percent</th>
<th>Speed in percent of critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>20%</td>
<td>0.53</td>
</tr>
<tr>
<td>40%</td>
<td>0.37</td>
</tr>
<tr>
<td>60%</td>
<td>0.32</td>
</tr>
<tr>
<td>80%</td>
<td>0.25</td>
</tr>
<tr>
<td>100%</td>
<td>0.20</td>
</tr>
</tbody>
</table>

It will be observed in Table I that variations in the percentages of the voids in the charge of grinding bodies, which are occupied by the slurry, have little effect on the power consumption when the mill is rotated at normal speeds. At the critical speed, the power consumption reaches a maximum when the slurry occupies about 60% of the voids in the charge of grinding bodies and it has been found that, at super-critical speeds, the power consumption reaches a maximum when the slurry occupies 60% to 70% of the voids in the charge of grinding bodies.

In another series of tests, the slurry occupied 70% of the voids among the grinding bodies at all times and the yield value of the slurry and the speed of rotation of the mill were varied. The results of these tests are shown in Table II.

<table>
<thead>
<tr>
<th>Yield Value, dynes/cm(^2)</th>
<th>Speed in percent of critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>200</td>
<td>0.49</td>
</tr>
<tr>
<td>300</td>
<td>0.36</td>
</tr>
<tr>
<td>400</td>
<td>0.31</td>
</tr>
<tr>
<td>500</td>
<td>0.27</td>
</tr>
<tr>
<td>600</td>
<td>0.23</td>
</tr>
<tr>
<td>700</td>
<td>0.20</td>
</tr>
<tr>
<td>800</td>
<td>0.17</td>
</tr>
</tbody>
</table>

An examination of the test results contained in Table II shows that variations in the yield value of the slurry have a comparatively little effect on the power consumption at normal mill speeds. At the critical speeds and at 140% of the critical speed, the power consumption is a maximum, when the slurry has a yield value of 600 dynes/cm\(^2\) while, with a mill speed of 120% of the critical speed, the...
maximum power consumption occurs when the slurry has a yield value of 800 dynes/cm². The test results with
the mill operating at critical and super-critical speeds indicate that the yield value of the slurry is of substantial
importance. If the slurry has too high a viscosity, the grind-
ing bodies and slurry stick to the mill lining by centrifugal
action so that grinding is impossible. The consistency of
slurry should, accordingly, be slightly thinner than that
which results in the grinding bodies and slurry being
held against the mill lining by centrifugal action.

In the practice of the method of the invention, it is
desirable that the introduction of water into the mill be
automatically regulated on the basis of a continuous de-
termination of the consistency of the mill slurry and such
regulation may be accomplished by the use of the vis-
cometer and associated control devices disclosed in the
British patent specification 624,468.

In the practice of the new method, the use of mills of
the well-known grate-discharge type is preferred and it
is advantageous to employ a mill, in which the ratio of
length to diameter ranges from 0.5 to 2 and is pref-
erably about 1. Such a grate-discharge mill may have
discharge slots in a plane end wall or through the cylin-
drical shell of the mill, the slots being of a width small
enough to prevent the grinding bodies from passing but
wide enough to permit the ground material to be dis-
charged for collection in a hopper below the mill. Such
a mill is to be distinguished from an overflow mill, in
which the ground material is discharged through an axial
hollow trunnion. Grate-discharge mills, which may be
advantageously employed in practicing the method, may
be divided into two compartments having discharge slots
close to a central partition separating the compartments
and inlets for feed at opposite ends. The use of the sepa-
rate discharge outlets from the two compartments permits
the consistency of the slurry in the compartments to be
separately checked. The material discharged from one
compartment may be conveyed to the inlet of the other
or the grinding in either or both compartments may be
in closed circuit.

1 claim:

A method of grinding a slurry of mineral material which
comprises introducing into a rotary drum a charge of
non-metallic grinding bodies and a quantity of slurry
sufficient to occupy from 40% to 80% of the voids among
the bodies and of a yield value in the range of 300 to
900 dynes/cm², rotating the drum at a speed in the range
from just below the critical speed to about 150% of the
critical speed, withdrawing from the mill slurry contain-
ing particles below a selected size, and introducing into
the mill slurry of a yield value within the specified range
at a rate sufficient to maintain the specified quantity of
slurry within the mill.

References Cited in the file of this patent

UNITED STATES PATENTS

2,754,067 Klugh __________________ July 10, 1956
2,766,940 Weston __________________ Oct. 16, 1956
2,824,701 Vester et al. ____________ Feb. 25, 1958

OTHER REFERENCES

Taggart, Handbook of Mineral Dressing, pages 5–122–
5–123 (copy in Scientific Library).