APPARATUS FOR GRINDING MINERAL MATERIALS

4 Claims, 8 Drawing Figs.

ABSTRACT: Granular mineral materials are ground in a rotating mill having at least one partially confined grinding compartment. The material is fed through a constricted opening into one end of this compartment, atmospheric air being permitted to enter in the same way. The coarse material is gradually ground down into finely divided form and is discharged through a constricted opening into an adjoining collection compartment and thence discharged from the mill. The rate of feed of the coarse material into the grinding compartment and the rate of discharge of the ground material therefrom are so controlled that a pool of the finely ground material is maintained in the grinding compartment which is so fluidized that it behaves like a liquid. The apparatus is a tube mill having one or more grinding compartments. If there is only one grinding compartment a narrow collection compartment is located on the downstream side and if there are two grinding compartments the second one is on the downstream side of the narrow compartment. The wall of this compartment adjacent the grinding compartment includes a screen section, and the opposite wall a dam ring and overflow opening.
APPARATUS FOR GRINDING MINERAL MATERIALS

BACKGROUND OF THE INVENTION

The dry grinding of coarse granular materials, such for instance as cement clinker, is commonly effected in tube mills containing grinding bodies. Such a mill may have only one grinding compartment, but more often it has two or more grinding compartments each separated from the next by a diaphragm through which sufficiently ground material can pass. It has hitherto been considered important to insure that material sufficiently ground to pass through the diaphragm provided between the first compartment and the next be removed as fast as it is produced by the impact of the grinding bodies. Otherwise the fine ground material is thought to interfere with the grinding by building up a protective layer on the grinding bodies and the coarse material.

When the first grinding compartment is overfilled, caused either by an increased feed of coarse material or by a decrease in the discharge of ground material from the mill, backspill may occur. On the other hand, if the feed is too slow, less finished product is produced, and the wear on the grinding bodies and mill lining, which is always considerable, is increased. There is an optimum rate of feed which should be maintained.

The mill produces a great deal of noise in operation, so much in fact as frequently to be a nuisance to the mill operators and attendants and may even be dangerous to their health. In some cases the noise problem may be solved by insulating the mill proper, for example by interposing insulating material between the mill shell and the lining, or by making a separate building enclosing the mill and isolating it from the surroundings. The noise serves a useful purpose, however, in that it increases if the feed is too slow and decreases if it is too fast. An experienced mill operator is capable of controlling the feed to the mill according to the grinding noise emitted from the mill. Moreover, the control can be made automatic by equipping the grinding plant with a microphone, a transmitter and an amplifier by means of which the sound is converted into a suitable control signal which alone or in combination with other signals is used to control the feed to the mill.

SUMMARY OF THE INVENTION

According to the invention the rate of feed to the mill through a constricted opening in one end wall of the mill and the rate of discharge from the first or sole grinding compartment are so controlled that part of the ground product, although ground to such an extent as to be capable of passing out of the grinding compartment, is prevented from leaving it, with the result that a permanent pool of ground material forms and is maintained at the bottom portion of the confined grinding compartment. This pool is so aerated and fluidized during the motion of the charge by air already in and entering the grinding compartment as to behave as a liquid. The finely ground material from the pool is gradually screened out at the discharge end of the grinding compartment and collected in the adjoining narrow compartment. The material is gradually removed from the collection compartment through a constricted discharge opening. This rate of discharge controls the rate of feed of coarse material to the confined grinding compartment.

We find that the wear is reduced because of the high proportion of fine material that is present in the grinding compartment, and that there is an increase in the efficiency as measured by the power consumption. In addition the noise is reduced, and the grinding process can be carried on with a grinding noise lower than was previously considered desirable, and yet the feed to the mill can still be controlled by the noise.

In order to maintain the pool of ground material in the first or sole grinding compartment, it is necessary to construct the mill appropriately. The invention includes novel tube mill constructions suitable for carrying out the method and including a relatively narrow compartment located downstream of the first or sole grinding compartment and adapted to serve as a reservoir of fluidized ground material. The partition between the first or sole grinding compartment and the narrow reservoir compartment is constructed to enable the fluidized ground material to flow from either compartment to the other.

The narrow reservoir compartment is bounded downstream by a wall having one or more openings through which the ground material can pass and which are so located that the continued grinding operation produces a permanent pool of substantial depth which is maintained in the narrow reservoir compartment.

If there is only one grinding compartment, the wall bounding the narrow reservoir compartment downstream is constituted by the end wall of the mill containing the discharge opening which is through a hollow supporting trunnion for the mill tube. More commonly, however, tube mills have more than one grinding zone or compartment, and in this case the narrow reservoir compartment is preferably intermediate the first and second grinding compartments and is bounded downstream as well as upstream by a partition.

The provision of an intermediate compartment in a mill is known, but hitherto the reason for providing it has been to improve the movement of the ground product through the mill, and lifters or the equivalent have been provided for discharging the intermediate compartment as fully and quickly as possible. In the present invention there may not be lifters, but there may advantageously be scoops working in a central area to limit the depth of the reservoir of fluidized material.

It is found in practice that there is sometimes a tendency for the pool in the narrow compartment to be undesirably reduced as a result of discharge of material at a greater rate than that of entry, and indeed the narrow compartment is sometimes emptied. The reason for this is that the fine material is positively lifted above the opening in the downstream or partition wall and on falling down again passes through the opening. The wall or partition is of course built up from individual elements, and bolt heads or other projections tend to lift the material, particularly when this is sticky, for example lime.

Such undesired discharge from the narrow compartment may be prevented by shrouding the central opening through which the discharge takes place so that material falling downwards is deflected and so prevented from passing through the opening. The tendency to the undesired discharge may be reduced also by increasing the fluidization of the pool in the intermediate compartment. This may be done by providing stirrers or by introducing fluidizing air through air-permeable plates at the peripheral wall of the intermediate compartment.

BRIEF DESCRIPTION OF THE DRAWINGS

Several embodiments of the invention are shown by way of example in the accompanying diagrammatic drawings, in which

FIG. 1 is a vertical section through the inlet end and the first grinding compartment of one compartment mill; FIG. 2 shows a vertical section through the inlet end and the first grinding compartment of another mill; FIG. 3 shows a modification of the mill of FIG. 1; FIG. 4 is a section on the line 1—1 of FIG. 5; FIG. 5 is a section on the line 5—5 of FIG. 3; FIG. 6 shows the distribution of the charge and material in the grinding compartment diagrammatically; FIG. 7 is a vertical section similar to FIG. 1 through a modified mill; and FIG. 8 is a section on the line 8—8 of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment shown in FIG. 1 includes a mill shell 1 or tube 1 with a wear-resistant lining 2 and is carried by hollow trunnions, of which only the section 3 at the inlet end is shown. These hollow trunnions form constricted inlet and discharge openings for the material. Material to be treated in
the mill is fed through the central opening 4 of one of the trun-
nions into a first grinding compartment 5, which is separated
from a second grinding compartment 7 by a narrow inter-
mediate reservoir compartment 6 bounded by two partitions 8
and 9. The partition 8 comprises an imperforate rim portion
16 and a center portion 17 with an annular screen portion 15
between them. The partition 9 is a dam ring with a single
central opening 14. The meshes of the screen 15 allow ground
material but not grinding bodies to pass.

Coarse material to be ground is fed substantially continu-
ously through the opening 4 to the first grinding zone or com-
partment 5, which contains a suitable amount of grinding
bodies (not shown). The ground material can leave the grind-
ing compartment 5 through the screen 15 in partition 8, and
pass into the intermediate reservoir compartment 6. As it can
leave this only by overflow through the central opening 14 of
dam ring 9, a reservoir of ground material is maintained in
the intermediate compartment 6. The charge in the grinding zone
or compartment 5 is composed of two parts as indicated in
FIG. 6. One part 19 comprises a mixture of grinding bodies
and of material being treated in various stages of reduction.
Because of the rotation of the mill, indicated by the arrow, and
the friction between the lining 2 and the charge, this part 19 is
in continuous motion, being lifted above the axis of the mill
and then sliding and tumbling downwards.

The second part of the charge in compartment 5 consists al-
most exclusively of ground product which is fluidized by air
during the violent agitation of the charge. The fluidization is
assisted by ventilating air which is drawn through the mill as
usual. The fluidized mass of ground product forms a pool 20
which behaves like a liquid, and if it could pass freely out of
the grinding compartment 5 it would do so. However the reser-
voir of material in intermediate compartment 6 inhibits the
passage of the ground material into the intermediate com-
partment, except at the same rate as ground material passes
through the opening 14 in the dam ring 9, and causes ground
material to build up to the same level against the partition 8
in the grinding compartment 5. Thus, contrary to conventional
practice, the first grinding compartment 5 is permanently
overfilled.

The existence of the pool 20 of fluidized ground material in
grinding compartment 5 is advantageous as it protects the
wearing plates at the toe of the mixture 19 of grinding bodies
and coarse material against the impact of the grinding bodies.
Part of the ground material is continually lifted or pumped out
of pool 20 so as to form a constituent of the part 19 and par-
take in the continuous movement of this part. Ground materi-
al continuously leaves this part 19 to enter the intermediate
reservoir compartment 6. In addition the pool reduces the
noise.

In FIG. 2 two different partitions 10 and 11 bounding the in-
termediate reservoir compartment 6 are shown. The partition
10 includes a screen 21 that extends as close as is feasible to
the mill lining 2, and the partition 11 is a dam ring with a
screen 22 over its central opening. This screen 22 serves to
prevent grinding bodies in the second grinding compartment 7
from entering the intermediate reservoir compartment 6.

If it is desired to increase the ease of flow of ventilating air
through the mill, it is desirable to use a partition such as 10
with its increased area of opening, rather than that shown at 8,
and to use a partition such as dam ring 9 which has no screen.

Increased control over the level of the fluidized material in
the intermediate compartment 6, and therefore over the
volume of the pool 20 of fluidized material, can be obtained
by the provision of apparatus for discharging material from a
central zone in the intermediate compartment 6. One such ap-
paratus is shown at 12 in FIGS. 3 and 5 and comprises scoops
13 carried by radial vanes 18 which are mounted on supports
not shown and which guide the scooped material to the open-
ing 14 in the partition or dam ring 9. These scoops 13 cannot
empty the intermediate compartment 6 of ground material,
but in practice they maintain it at a desired level. Their outer
ends should be located at a substantial distance from the wall
of the mill, and the desired level can be adjusted by cutting off
part of the end of each scoop after the apparatus has been in-
stalled in the mill.

FIGS. 7 and 8 diagrammatically show a construction by
which the tendency for the pool of fluidized material in the
intermediate compartment 6 to be undesirably reduced or even
emptied is effectively eliminated. In this construction there is
an intermediate compartment 23 bounded by partitions 24
and 25 which are joined by staybolts 26. The partition 24 has a
solid center portion 27 and rim portion 28 with an annular
screen 29 between them. The center 27 carries a frustoconical
ring 30. The partition 25 has a central opening 31, which is
surrounded within the compartment 23 by a frustoconical ring
32 which embraces the ring 30.

FIG. 8 shows a fluidized pool 33 from which material tends
to be carried upwards as shown at 34 to fall downwards as
shown at 35. It will be seen that the rings 32 and 30 effectively
shroud the opening 31, while allowing material from the sur-
face of the pool to pass. The staybolts 26 stir the pool and help
to keep it fluidized.

1 claim:

1. A tube mill having at least one grinding compartment
having grinding bodies therein, means for maintaining a pool of
fluidized ground material therein including a relatively narrow
collection compartment located downstream from the grind-
ing compartment and serving as a reservoir of fluidized ground
material, and a screen between the grinding compartment and
the narrow collection compartment constructed to allow the
fluidized ground material, but not grinding bodies, to pass
from either compartment to the other, and the narrow collec-
tion compartment being bounded downstream by a wall hav-
ning at least one opening through which the ground material
can pass to maintain the depth of said pool desired.

2. A tube mill having at least one grinding compartment
having grinding bodies therein and a permanent pool of
fluidized ground material, a relatively narrow collection com-
partment located downstream from the grinding compartment
and serving as a reservoir of fluidized ground material, a
screen between the grinding compartment and the narrow col-
lection compartment constructed to allow the fluidized ground
material, but not grinding bodies, to pass from either
compartment to the other, and the narrow collection compart-
ment being bounded downstream by a wall having at least one
opening through which the ground material can pass, the col-
lection compartment being provided with scoops the outer
ends of which are located at such a distance from the peri-
pheral wall of the mill that in operation a pool of substan-
tial depth always exists in the narrow collection compartment
thereby controlling the depth of the pool of ground material in
the grinding compartment.

3. A tube mill according to claim 2 having two grinding
compartments and a relatively narrow collection compart-
ment disposed between the two grinding compartments, and a
partition between the collection and second grinding compart-
ments having a single-central opening such that in operation a
pool of ground material of substantial depth always exists in
the intermediate compartment.

4. A tube mill according to claim 3 in which a shroud ex-
tends around said single central opening to deflect down-
wardly flowing material and preventing it from passing
through the opening in the backward direction from said
second grinding compartment to said collection compartment.