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Putman

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[54] **CONTROL SYSTEM AND METHOD FOR A REVERSED BALL MILL GRINDING CIRCUIT**

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[52] **U.S. Cl.** **241/30,** 241/34

[51] **Int. Cl.** **B02c 25/00**

[58] **Field of Search** 241/33, 34, 30

[56] **References Cited**

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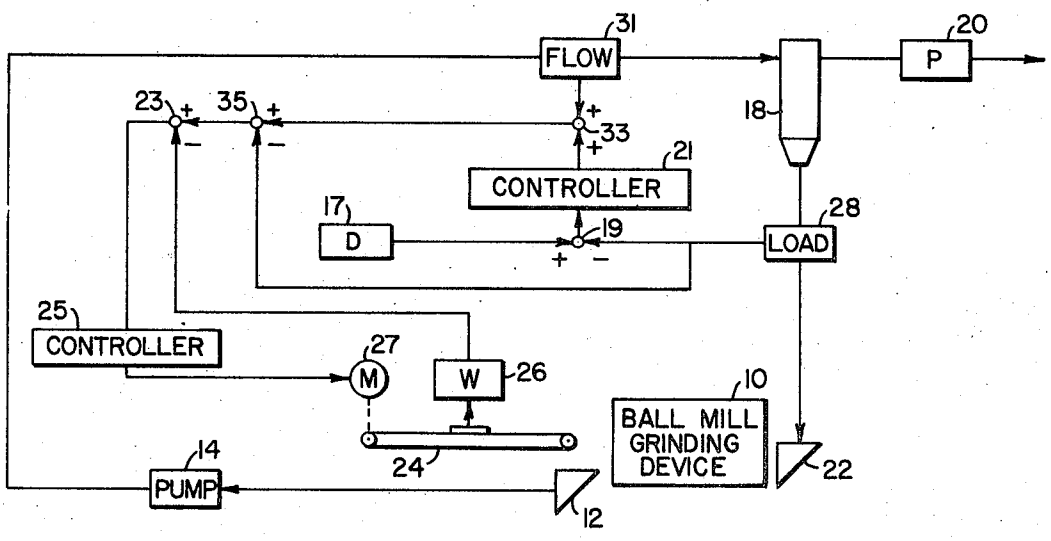
Primary Examiner—Granville Y. Custer, Jr.

Attorney—F. H. Henson et al.

[57] **ABSTRACT**

The dynamically fast in response and stable control arrangement for a reversed ball mill grinding circuit, which operates in accordance with the basic control algorithm that the new material feed rate to the reversed ball mill grinding circuit is controlled as a function of the net output solids flow production from the production cyclones associated with that grinding circuit plus the integral of the error between the desired solids flow load and the actual solids flow load of the grinding mill associated with that circuit.

7 Claims, 5 Drawing Figures



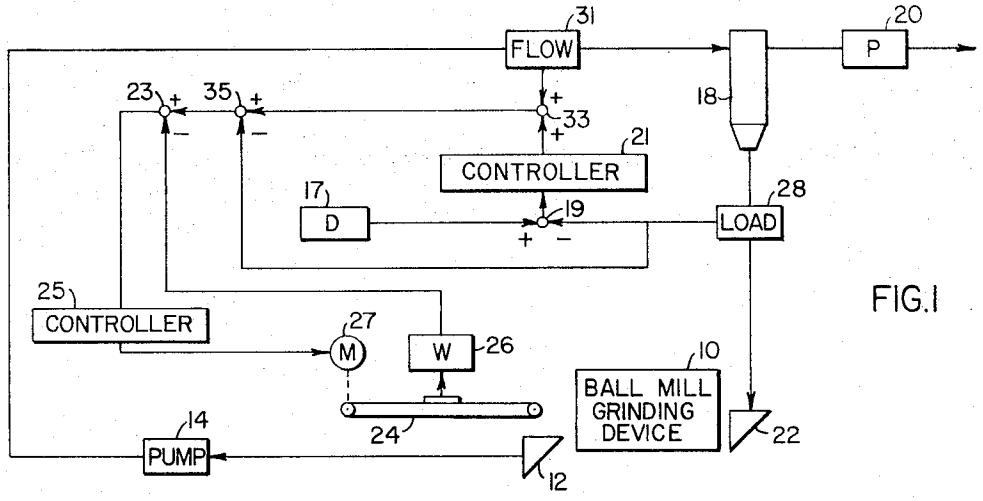


FIG.1

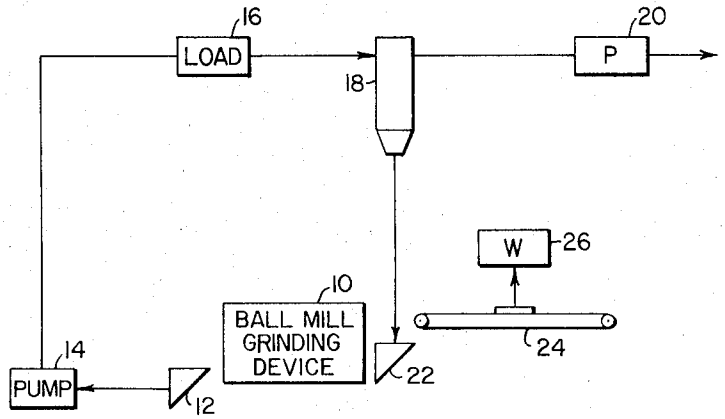


FIG.2

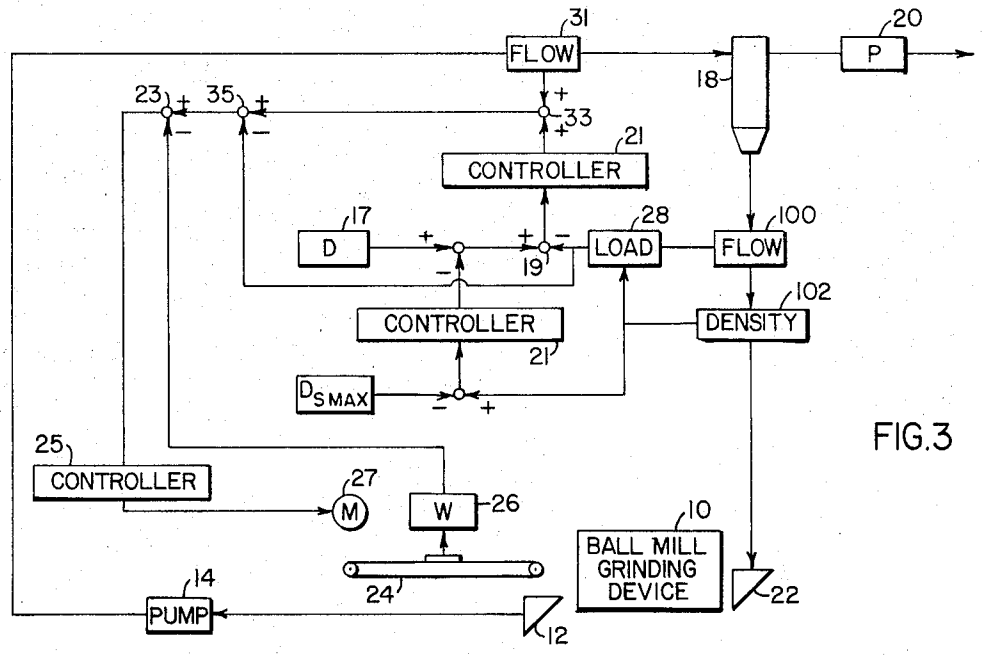


FIG.3

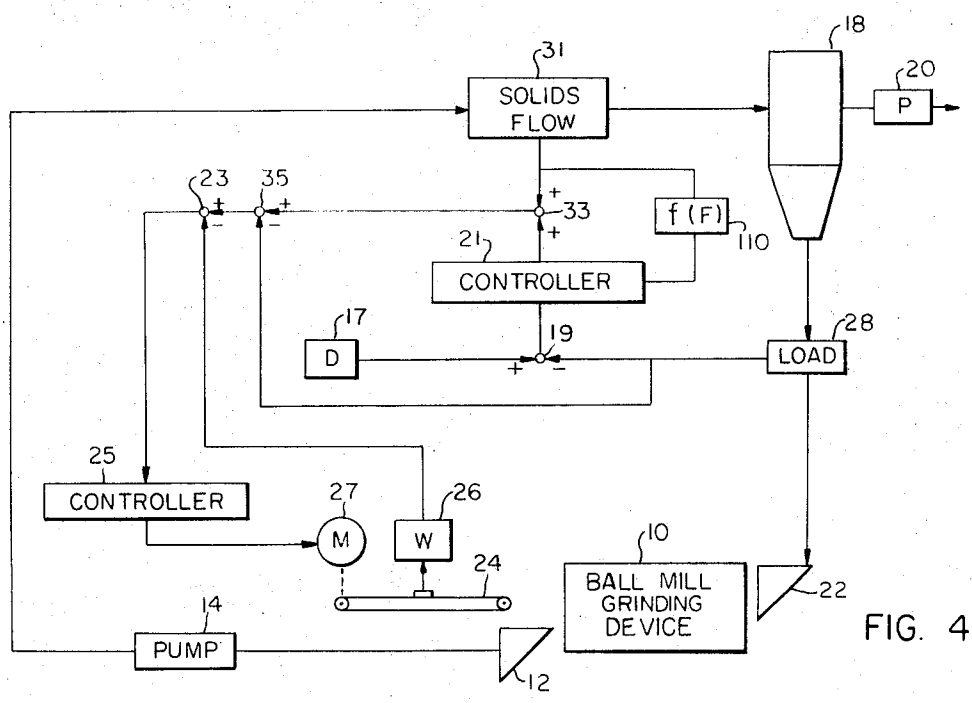

31
SOLIDS FLOW
18
20
P
23
35
33
f (F)
110
21
CONTROLLER
17
D
19
28
LOAD
25
CONTROLLER
27
M
26
W
24
10
BALL MILL GRINDING DEVICE
22
14
PUMP
12

FIG. 4

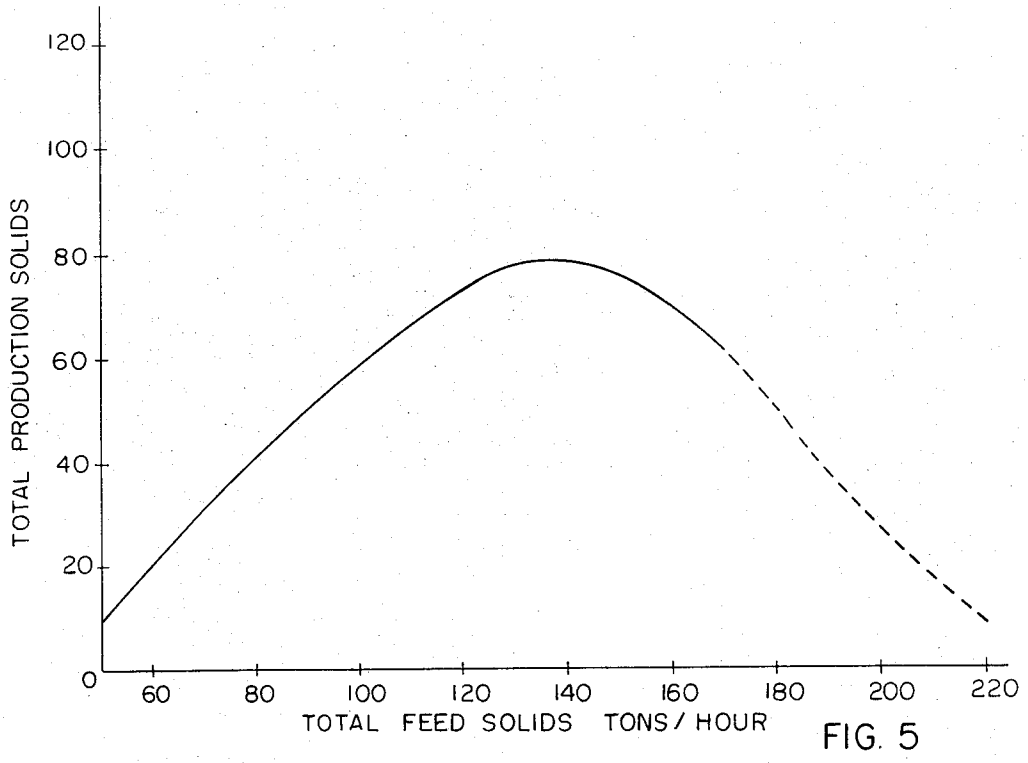

120
100
80
60
40
20
0
TOTAL PRODUCTION SOLIDS
60
80
100
120
140
160
180
200
220
TOTAL FEED SOLIDS TONS / HOUR

FIG. 5

CONTROL SYSTEM AND METHOD FOR A REVERSED BALL MILL GRINDING CIRCUIT

BACKGROUND OF THE INVENTION

In the present state of the art there are few ball mill grinding devices that have any type of load control. Regulation of the rate of feed of new material to a grinding mill circuit has been tried, whether the grinding mill circuit is arranged in a normal or a reversed circuit arrangement, at a substantially constant rate. The result has been that while the grinding mill circuit might for a time run freely and without plugging, with an ore of a certain hardness in a certain feed size distribution, should either of the latter parameters change dramatically, such that the ore becomes harder or the feed size coarser, additional recycling of ore material will occur within the grinding mill circuit and the production rate or the feed rate that was present before now becomes excessive such that the grinding mill can tend to plug. For a change of hardness or feed size distribution, becoming coarser or the hardness increasing, the mill will tend to plug when run at the maximum mill throughput. It is therefore desirable to run as close to maximum throughout as is reasonably feasible to do so because the grinding mill is a bottle neck in the total ore processing plant, whereas the production cyclones are very seldom the bottle neck and the available rate of feed of new materials is usually far in excess of what the grinding mill circuit can accept. It is the throughput in the ball mill, which can be tolerated without plugging, that is the limiting parameter for the ore processing plant. Plugging occurs when there is produced less fines without being cycloned off than the new material feed coming in, such that there occurs a buildup of material in the grinding mill circuit and the circuit jams up solid if it is allowed to go on in this manner. This can occur during transients since it takes approximately three retention times before the grinding mill circuit will settle down again and transients can become a cause of very heavy mill throughput for a short period of time such that a plugging condition can result.

It has been known in the prior art to measure the inventory of material in the ball mill in relation to the pressure of the oil at the bearings, which pressure generally bears a somewhat linear relationship to the load on the ball mill bearings, and therefore the load in the grinding mill itself. However, the grinding mill inventory is not necessarily a measure of material throughput because the same inventory can be present in the grinding mill even though the flow rate through the grinding mill is varying and of course the load on the grinding mill bearings can vary with the ball charge or bearing wear so several assumptions have to be made when measuring the bearing oil pressure as compared to measuring the actual ore material flows in and out of the grinding mill.

It is desirable for the operation of a ball mill grinding device that any condition of input material change, such as a change in the slurry containing the ore to be ground, does not result in a wide variation in the operating level of the ball mill. The ball mill should be operated to avoid plugging as an indesired condition of operation and it should be operated at an optimum critical level of operation to be maintained which is below the throughput of ore material at which the ball mill is likely to become plugged and is still high enough that the throughput of material is in effect maximized. In actual practice, a ball mill grinding device will malfunction slightly before the plugging condition, and therefore this optimum critical level of operation should be selected to maintain a desired operation of the ball mill in consideration of an optimized or substantially maximum throughput of material to be ground passing through the ball mill grinding device.

In the operation of a well-known normal grinding circuit the new material from a supply conveyor is added to the underflow material from the production cyclone at the input of the ball mill. In the operation of a well-known reversed circuit ball mill grinding device, the new material is added from a supply conveyor to the output of the ball mill and then passes through the production cyclones before the larger sized portion of the new material is recycled to enter the input of the ball mill.

For a reversed circuit operation of a ball mill operative with production cyclones, the new material to be ground is fed into a collection hopper located at the output of the ball mill such that new ore material added to the circuit first passes through the production cycles and is classified relative to particle size before the larger sized portion of this new material passes through the ball mill. In this way, the new material having a particle size smaller for example than 200 mesh if the latter size is the chosen particle size split of the production cyclones, would be separated by the production cyclones to pass as overflow to the subsequent mineral separation process such as flotation cells and not pass through the ball mill. On the other hand the new ore material particle sizes larger than 200 mesh would be split away from the smaller particle size material and pass as the underflow from the production cyclones to the input of the ball mill.

The mean maximum throughput of ore material passing through the ball mill is the desired operation of the ball mill in that this will in effect, maximize the amount of ore material passing through the operation including the ball mill. However, it is desired to avoid surging or substantial increases in this level of material throughput in that otherwise it is likely that the ball mill will pass into an undesired plugging condition of operation on the one hand or the amount of material passing through the ball mill may decrease below this mean maximum or optimum desired amount and this reduces the amount of material that is processed by the reversed grinding circuit apparatus. For a desired return on equipment investment, it is desired that a maximum tonnage of ore material be passed through the ball mill and associated apparatus consistent with the product having the desired particle size distribution. A typical ball mill grinding circuit may process in the order of 150 to 200 tons per hour of new ore material so a small percentage increase in this throughput can be economically very significant. A typical human operator may consistently operate a ball mill at about 5 percent below the theoretical desired material throughput where plugging is likely to occur; the operator desires the operational throughput as high as possible but he is concerned about avoiding a plugging condition for the ball mill. One cause of surging of a ball mill is variation in the hardness of the ore material passing through the ball mill and this in effect varies the load on the ball mill and causes its operation to vary in an undesired surging manner.

The prior art practice for the control of a reversed grinding circuit is to provide a control system responsive to a first signal related to the sensed weight of the new ore material as sensed by a weight responsive device and a second signal related to the conveyor belt speed for the control of new ore feed rate substantially constant. The latter control system is usually set such that with the present ore material the grinding mill is running at less than full optimum capacity in order that an increase in the hardness or a more coarse feed size distribution will not cause the grinding mill circuit to plug as an overload condition in which the grinding circuit becomes choked and effective grinding cases.

A sonic type mill load controller has been used which regulates the new feed rate to the grinding circuit such that the sound emanating from the ball mill is maintained at a desired level. This has been found to work fairly well on cement grinding circuits where friable material is involved. However, it does not work satisfactorily with hard ores and is affected by the weight of the ball charge and slurry consistency such that the more viscous slurries may dampen the resulting noise.

It is generally recognized that grinding mill throughput is the primary constraint on the grinding circuit capacity such that maximum production of ground ore and the desirable particle size distribution can thereby be obtained and an attempt to control the grinding mill load with precision even under changes in hardness, feed size distribution or cyclone classifier aperture openings means that the grinding circuit will run more constantly at this constraint and so be maximized.

SUMMARY OF THE INVENTION

The present invention provides for the control of new feed rate W of new ore material, supplied to the hopper at the output of the ball mill grinding device, to be equal to P the cyclone output production rate, plus the mill load error (D-L) where D is the desired or reference ball mill load and L is the actual measured ball mill load. In relation to the above, flow of materials P is the cyclone total production as measured with flow and density meters, D is the desired ball mill material load flow, L is the actual ball mill solids material load flow and W is the controlled flow of new ore material entering the grinding mill circuit. For steady state operation the cyclone solids production flow P should equal the new ore material flow W supplied to the grinding mill circuit. For the purpose of controlling the new material supply conveyor it is desired to compare a signal dependent upon the measured flow of new material W_A with another signal related to the calculated reference flow of desired new material W_R needed for the desired operation of the ball mill grinding circuit.

For the control of the material throughput of a grinding mill, it is desired to optimize and maximize the production rate subject to the constraints of particle size distribution fraction less than some desired size such as 200 mesh in size, the overflow density should be greater than a predetermined desired value and the underflow density should be less than a predetermined desired value and it is desired to keep the grinding mill throughput at a substantially maximum and critical value. To be able to achieve the optimum operation and promptly return it after a disturbance the ability to manipulate various setpoints is required such that the grinding apparatus will achieve the desired operating setpoints quickly and without overshoot to satisfy the requirement that the grinding mill circuit operate as desired and be stable under all operating conditions.

One of the most important setpoints from this is the mill throughput since it is a principle constraint on the operation of the grinding mill circuit. To be able to hold throughput at some maximum value and prevent choking of the mill under all conditions further increases the available production of new ore material by raising the mean throughput in conjunction with a reduction in down time. Further, the desired control of the grinding mill throughput also controls the retention time for a given ore hardness and stabilizes the mill and cyclone product size distribution. Some typical disturbances include changes in the number of production cyclones, changes in their inlet velocity and/or density and in the grindability or feed size distribution of newly supplied ore material.

The present control arrangement resulted from the recognition of a problem of dynamic stability in reversed ball mill grinding circuits where the load to the ball mill is attempted to be held constant. For any circuit normal or reverse, if the feed rate is held constant there will occur an equilibrium position at which the grinding mill circuit will settle down in its operation. The inherent instability of the reversed circuit does not occur when only the new feed rate is held constant, but rather it occurs when an attempt is made to hold the mill load constant by varying the new feed rate. The instability problem is created by the delayed effect of the new material coming back through the grinding mill. The present control arrangement is dynamically fast in response and stable, and operates in accordance with the basic algorithm that the new feed to the mill is controlled as a function of the net production from the cyclones plus the integral of the error between the desired load for the grinding mill and the actual load to the grinding mill. This means that when the grinding mill circuit is running under equilibrium conditions, at desired mill load, and suddenly the new ore material changes in its feed size distribution to become finer or easier to grind, there occurs a change in production such as an increase and a corresponding and immediate reduction in the amount of material reporting to the mill. An effort at this time to increase the new feed to the mill to compensate for the loss of ore going into the mill results also in an increase in the underflow reporting to the mill, but by only a portion of the new feed change so that the load on the ball mill is not brought back to where it was before since the change in the new feed will produce less than the desired change in the feed rate or in the load on the mill itself because of the varying gain of the production cyclones.

The speed of response is high so the control will tend to hold the mill load substantially constant or even raise it slightly. The delay in the control effect should then start to cut it back to where the actual load is the same as the desired load. The proportional effect is achieved in relation to a change in production and the reset effect is achieved in relation to the difference between the desired load in the actual load on the grinding mill.

The gain on the system which gain is the ratio of the change in ball mill load or the cyclone underflow to the change in new material feed rate, changes from zero at a low mill throughput, through unity and up to as much as a gain of two, and this presents a rather difficult control situation. For this purpose, the here-disclosed control arrangement regulates the new ore feed rate as de-

sired to provide a stable operation of the grinding mill circuit. In relation to the error in mill load, as the difference between the desired mill load D and the actual mill load L which is sensed as underflow from the cyclone L, this difference is the operational error on the grinding mill circuit and goes to a proportional plus reset controller. The output of which provides the set point for the new material feed rate to the cyclone. The error generated between the output of the first controller and the cyclone feed goes to a second controller, the output from which sets the new ore feed rate through the ball mill. If an error is established in the mill load, and the flow rate to the cyclone is adjusted by regulating the new feed rate to the mill, the feed to the cyclone relates to the production from the cyclone, with the gain being defined in terms of the ratio of the change in underflow or ball mill throughput for a change in new feed, which is the control system gain of interest. It is the underflow leaving the cyclones or the material flow to the ball mill that it is desired to regulate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic diagram of a control arrangement for a reversed ball mill grinding circuit in accordance with the present invention;

FIG. 2 shows an illustrative schematic diagram of a well-known normal ball mill grinding circuit;

FIG. 3 shows a modification of the FIG. 1 schematic diagram to include a desired maximum slurry density constraint on the control system arrangement;

FIG. 4 shows a modification of the FIG. 1 schematic diagram to include a gain variation for the operation of the reset controller in accordance with the cyclone operating characteristic; and

FIG. 5 is a curve to illustrate the operating characteristic of a single cyclone classifier operative with a ball mill grinding device.

DESCRIPITON OF A PREFERRED EMBODIMENT

In reference to FIG. 1, new ore material is mixed in an output hopper 12 with the discharge material from the ball mill grinding device 10 and then is supplied by a pump 14 to the input of a production cyclone classifier 18, which is operative to separate the ground ore material below a predetermined particle size such as 200 mesh to the overflow output and to recycle the underflow and larger size material to an input hopper 22 leading to the ball mill grinding device 10. A controller 25 is operative with a motor 27 for determining the operation of the new ore material supply conveyor 24, including a weight measuring device 26 being operative to provide an actual weight W_A control signal to a summing junction 23 for determining the operation of the controller 25. A solids flow determining device 31, including a slurry flow sensing device and a density sensing device, is provided in the input to the cyclone classifier 18 for determining the solids flow of the slurry material leading to the classifier 18. A solids flow sensing device 28, including a slurry flow sensing device and a density sensing device, is operative in the underflow of the cyclone classifier for sensing the input load through the ball mill grinding device 10. Control signals from the load sensing flowmeter 28 and a desired load reference signal source 17 are supplied to a summing junction 19 and operative with a controller 21 in relation to the difference between the desired load and the actual load on the ball mill grinding device 10. The output of the controller is applied to a summing junction 33 as indicated which in turn is operative with a summing junction 35 such that the output of the junction 35 is a reference weight control signal W_R in accordance with the relationship

$$W_R = (F-L) + \int (D-L)\, dt \quad (1)$$

In the control arrangement shown in FIG. 1, the controller 21 is supplied with an input signal in accordance with the material load error on the ball mill grinding device 10, such that the desired load signal from the source 17 is combined with the actual load signal from the flow sensing device 28 and supplied to the controller 21. The summing junction 23 provides an output signal in accordance with the reference or material weight signal W_R in accordance with the above equation (1) relationship. The controller 25 is supplied a control signal in accordance with the relationship

$$W_{error} = W_R - W_A, \quad (2)$$

for determining the operation of the new ore material supply conveyor 24.

It should be understood that the controller 21 shown in FIG. 1 is a variable speed floating controller which reflects the integral of the load error (D-L), whereas the controller 25 is a proportional plus integral controller.

In FIG. 2, there is provided a general illustration of the well-known normal ball mill grinding circuit, wherein the ball mill grinding device 10 has its input hopper 22 supplied with the underflow recycled slurry material from the production cyclone classifiers 18 as well as the new ore material supply from the conveyor 24.

In relation to the control system shown in FIG. 1, the output production P as sensed by the solids flowmeter 20 from the production cyclones 18 is equal to the input material solids flow F minus the underflow solids flow material L in accordance with the relationship

$$P = (F\text{-}L) \quad (3)$$

Thusly, the control operation is such that the ball mill load error (D-L) plus the cyclone production rate P which is (F-L) can be utilized to determine the desired or reference feed rate W_R for the new material supply from the conveyor 24. Thusly, the control arrangement can be utilized such that the summing point 33 provides an output signal in accordance with the relationship F + $\int$ (D-L) dt and the summing point 35 provides the desired control signal W_R in accordance with the above equation (1). The summing point 23 then compares the desired or reference new material feed rate W_R with the actual material feed rate W_A from the sensor 26 and provides a W_{error} signal in accordance with the above equation (2) relationship to the controller 25 for determining the operation of the motor 27 and the new material conveyor 24.

There is a finite retention time period for newly supplied ore material to pass through the ball mill grinding device 10. Thusly, at any given point in time, the material leaving the ball mill does not equal the material entering the ball mill, and to obtain a desired maximum throughput of ore material passing through the ball mill

grinding device **10**, the input to the ball mill grinding device is varied as required to maintain this desired maximum throughput.

The operation of the new material feed conveyor **24** which supplies new ore material to the grinding circuit is controlled as necessary to maintain the desired optimum throughput loading of the ball mill grinding device **10**. The producting cyclones **18** are set to give the desired particle size split, the grinding device load quantity L is a measure of the total input material flow entering the ball mill grinding device **10** and for this reason, it is desired that the load L be held substantially constant so that the material passing through the ball mill grinding device **10** is thereby maximized. It should be understood that the quantity of load material L for a typical ball mill operation is in the order of 3 or 4 times the new ore material flow W_A supplied to the grinding circuit.

In a typical operation of a grinding circuit each ball mill is separately controlled with a substantially constant speed drive motor and is coupled to a bank of one or more production cyclones as necessary to handle the quantity of ore material that passes through the ball mill. One flotation cell may be provided for each ball mill or it could be operative with several ball mills depending upon the size of the flotation cell.

Only part of the new feed material goes to the ball material in a reversed circuit operation and this new feed material varies with the inlet velocity to the production cyclone in the feed size distribution. The inlet velocity to the production cyclone is varied by the level of material accumulating in the sump **12** before the pump **14** end by the supply of new ore material from the conveyor **24**. The surging of input material supplied to the ball mill is what varies the material throughput of the ball mill. The pulp density to the production cyclones and the particle size split as well as the inlet velocity to the production cyclones can also cause this surging.

A variable gain operation of the ball mill grinding device **10** in regard to new ore material supplied to the grinding circuit is inherent since the portion of new material that will pass through the ball mill is variable depending upon the operation of the production cyclone **18**.

The floating controller **21** shown in FIG. **1** for the load error (D-L) will provide a fast speed of response because the response of the ball mill load L to a change in the input flow F to the production cyclones **18** is relatively fast. By virtue of the sharp response of the load L to a change in the flow F, a floating controller will permit desired control system stability. The floating controller has a reset term and does not include a proportional term, so the rate of change of the signal is a constant times the error. If a proportional plus reset controller were to be used, the change would be a function of the ball mill load error plus the integral of that ball mill load error and this tends to slow down the response of the control system. For a very tight control loop, the floating controller **21** such as shown in FIG. **1** is inherently faster and tends to be more accurate. There is shown in FIG. **1** a control arrangement for generating the desired reference weight W_R which is the feed to the production cyclone **18** minus the underflow to give the present net feed (F-L) plus the integral of the error relative to the desired load D for the mill. The load to the mill has a double effect such that for an increase in W this will result in an increase in the flow F and the ball mill load L increases to give a double effect on the flow F from the change in new ore material supply W. It is desired to hold the input flow F to the production cyclones at some substantially constant value.

The reversed ball mill grinding circuit is used with ores that are quite friable like Galena or lead sulfide, which ores are crushed to produce a lot of fines and these can be initially passed through the production cyclones to permit separation of the material which is already a flotation size to thereby reduce the load on the ball mill grinding device **10**.

In general, a reversed grinding mill circuit is inherently unstable when new ore material feed is regulated to control the grinding mill throughput substantially constant. Although it may achieve a condition of equilibrium if the new feed rate and hardness and so forth are maintained substantially constant. This instability in relation to direct control from the grinding mill throughput is due to the fact that the slurry flow F leading to the production controller cyclone **18** is the sum of W + L and a change in W also produces a change in L of the same sign. Thusly, the gain of the control system is in accordance with the following relationship gain equals change in mill throughput divided by change in new material feed, and is therefore very high. Response to a disturbance is consequently slow with a good chance of overshooting the critical mill throughput rate, to result in plugging of the grinding mill during transient conditions. Instability is further assisted by the delayed effect of the changes in ball mill load L on the output production from the cyclone classifiers **18** after grinding due to the mill mixing lag and distance velocity lag and hence on the ball mill load L in the feedback loop. The full effect of any step changes such as a new condition of equilibrium even under otherwise steady state conditions is not reached until approximately three retention times have elapsed or three passes of feed material through the ball mill grinding device reporting initially to the underflow which must be made through the grinding mill before it can leave in the overflow from the production cyclones **18**. Since the new ore material feed W cannot be acceptably controlled directly from the ball mill load error (D-L) a more complex control scheme is required. The control problem is first complicated by the variable nature of the gain inherent in the cyclone characteristic, such that the result is a control system with a high and widely variable gain.

The control system arrangement shown in FIG. **1** is operative with the following control relationship

$$W = P + V + \Delta T/T \times (D\text{-}L), \tag{4}$$

where T is the integration time constant and should be in the order of ½ minute. The latter equation (4) relationship indicates the changes in new ore material feed W are made initially equal to changes in the production output P in an attempt to maintain total control circuit inventory substantially constant. Changes ΔP in production output P will also immediately subtract from ball mill load L and a part of the new ore material feed W will report to the ball mill load L leaving a residual error smaller than ΔP. For the purpose of comparison, a normal controller equation using a velocity logarithm is in accordance with the relationship

$$W_N = K_1 \times (D\text{-}L) + V + \Delta T/T \times (D\text{-}L), \quad (5)$$

where V is the past value of the reset term.

The term P in equation (4) is a feedforward term while the second term $V + \Delta T/T$ (D-) represents a variable speed floating controller which is acceptable due to the fast feedback of new material feed W on the ball mill load L. In equation (5), both terms are only a function of the error (D-L) and at equilibrium where D is equal to L, V must have changed until W at least equals P. In equation (4), V need not change since W is always forced to be equal to P. Thusly, in equation (4), V is only adjusted to integrate out the long-term error (D-L) and not to also replace the diminution of the proportional term K1 × (D-L) which is returned to zero at equilibrium. It is a residual feedforward effect of P in equation (4) which causes equation (4) to provide better stability.

To establish the solids flow rate of slurry material passing through a pipe or conduit, such as ball mill actual material load L, both a flowmeter and a density meter are required. As shown in FIG. 3, a flow sensing device **100** and density sensing device **102** are provided to enable a determination of the ball mill material load L. In addition, the slurry density from the sensing device **102** is compared with a desired and maximum value of this density $D_{s\ max}$ and combined with the desired or reference load signal D, as an upper density constraint to modify the desired maximum ball mill load D, such that the new ore material feed rate will be controlled accordingly.

The solids flow rate can be determined as the product of flow and density in accordance with the relationship

$$S = \left(\frac{62.3}{1-1_\rho}\right)\left(\frac{D}{62.3} - 1\right)F$$

where S is the solids flow rate in pounds per minute, F is the slurry flow in cubic feet per minute, D is the slurry density in pounds per cubic feet and ρ is the specific gravity of solids.

In FIG. 4 there is included an operational amplifier or function generator **110** which operates as a function of the sensed solids flow F to modify the operational gain of controller **21** in accordance with the slope of the cyclone operating characteristic.

In FIG. 5 there is shown a curve to illustrate a typical operating characteristic for a single cyclone classifier operative with a ball mill grinding device such as shown in the grinding circuit of FIG. 1.

What is claimed is:

1. In a control system for a ball mill grinding circuit including at least one production cyclone, the combination of

means for sensing the output material solids flow leaving the cyclone,

means for sensing the actual load material solids flow passing through the ball mill,

means for establishing the desired load material solids flow to pass through said ball mill, and

means for controlling the feed rate of new ore material to said grinding circuit in accordance with a predetermined relationship between said output material solids flow and the difference between said desired load material solids flow and said actual load material solids flow.

2. The control system of claim 1, with said predetermined relationship being

$$W_R = P + \int (D\text{-}L)\, dt,$$

where W_R controls the flow of new ore material to said grinding circuit, P is the output material solids flow, D is the desired load material solids flow and L is the actual load material solids flow.

3. The control system of claim 1, with the supply of new ore material to said grinding circuit being in accordance with the integral of said difference between the desired load material solids flow and the actual material solids flow.

4. The control system of claim 1, with said ball mill grinding circuit being operative in a reversed arrangement such that the new ore material passes to said production cyclone before passing to the ball mill and said actual load material solids flow is the underflow from said production cyclone.

5. The control system of claim 1, with said control of the new ore material feed rate being in accordance with the relationship

$$W_{error} = W_R - W_A$$

where W_{error} is the error in said feed rate to be corrected, W_R is the desired feed rate established by said predetermined relationship and W_A is the actual feed rate of new ore material.

6. A method for controlling a ball mill grinding circuit including at least one production cyclone, including the steps of

sensing the solids flow of output material leaving said grinding circuit from said production cyclone,

sensing the solids flow of the actual load material passing to said ball mill,

establishing a solids flow of the desired load material to pass through said ball mill, and

controlling the new ore material feed rate to said grinding circuit in accordance with a predetermined relationship between the respective solids flows of said output material, said actual load material and said desired load material.

7. The method of claim 6 with said ball mill grinding circuit being operative in a reversed arrangement and said control of the new ore material feed rate effects a substantially constant mill load.

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