United States Patent [19]

Carpenter et al.

[11] **3,735,869**

[45] **May 29, 1973**

[54] **CYCLONE PARTICLE SEPARATOR**

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[22] Filed: **Oct. 29, 1970**

[21] Appl. No.: **85,108**

[52] **U.S. Cl.** **209/211**

[51] **Int. Cl.** **B04c 5/30**

[58] **Field of Search** ....209/211, 144; 233/16, 19 A, 19 R; 210/197; 55/339, 340

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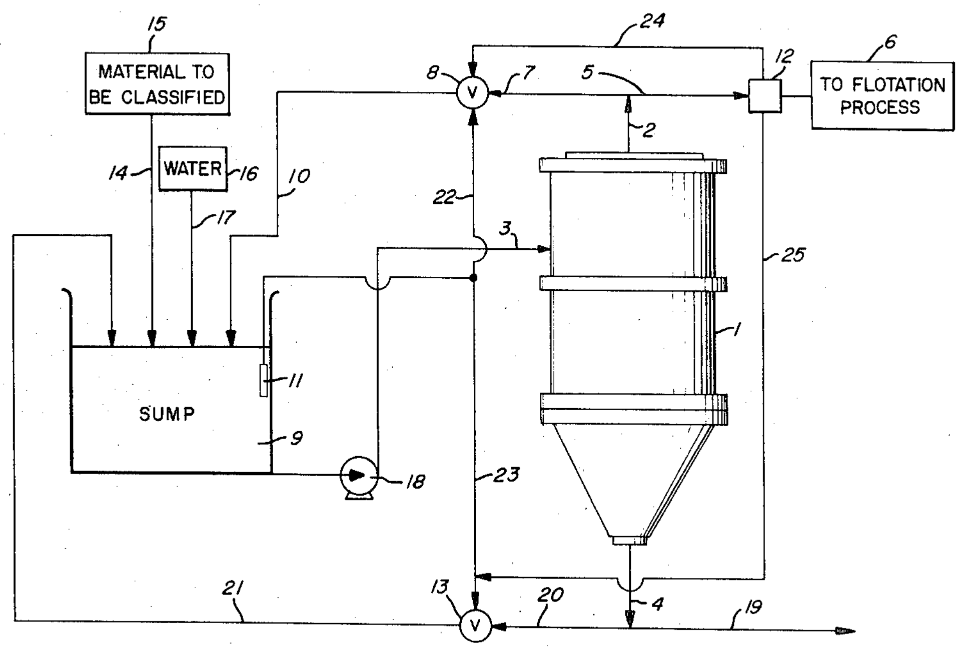
[57] **ABSTRACT**

A process and cyclone apparatus for the separation of particles within a liquified medium into fine and coarse particle solutions whereby the density of the fine particle solution is varied by means of recycling a portion of the fine and/or coarse particle slurry back into the input liquified medium.

7 Claims, 1 Drawing Figure



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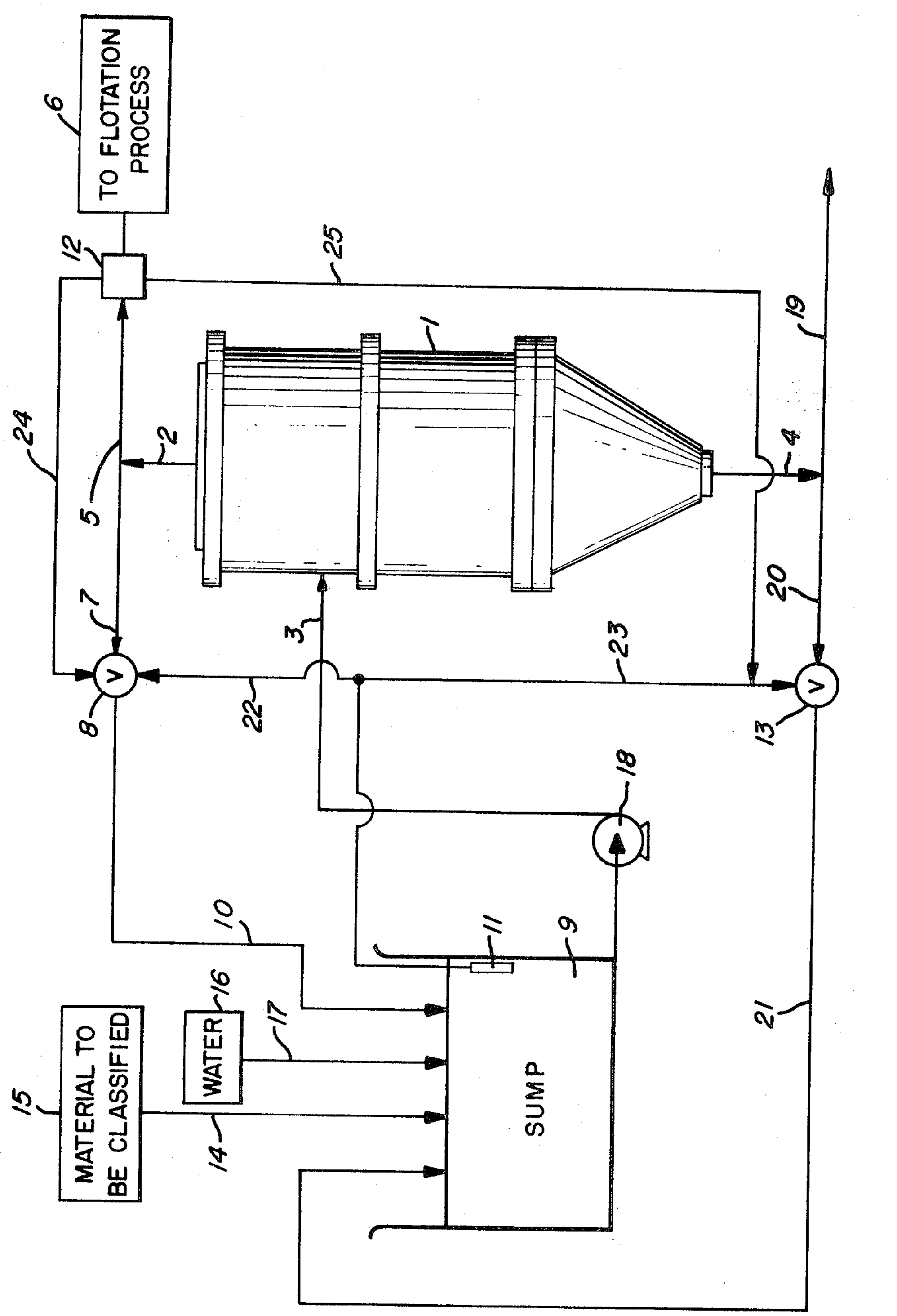

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CYCLONE PARTICLE SEPARATOR

FIELD OF THE INVENTION

This invention relates to a process and cyclone apparatus for separating or classifying crushed and/or ground material in a liquified medium into particulated fine and coarse particle solutions whereby the density of the fine particle slurry can be regulated without altering the density of the initial liquified medium being processed. In addition means are provided for insuring a constant input feed supply to the cyclone from the liquified medium.

DESCRIPTION OF THE PRIOR ART

Experimentation has indicated that cyclones could effectively be used to separate or classify various types of crushed or ground material into two different particle size composites. The centripetal and centrifugal forces encountered within a cyclone are used to separate the particles of the material whereby the larger or coarse particles would be forced to migrate to the outer circumferential vicinity of the cyclone while the smaller or fine particle size would be forced to migrate to the axial vicinity of the cyclone. The fine and coarse particles could then be discharged from the axial and circumferential vicinities, respectively, producing a separation of the initial material according to particle size.

"Particle size separation" refers to the physical size of a particle which upon being exposed to the centripetal and centrifugal forces within a cyclone would be acted upon by equal forces to project it to either the axial or circumferential vicinity within the cyclone. This particle size connotation is important when the axial discharge, called the overflow, is going to be used in a subsequent process or the like where the size of the particles in the overflow is critical. The circumferential discharge is called the underflow and contains the particles equal to or larger than the particle size separation.

The particle size separation dimension depends on many variables such as input feed density, inlet pressure, particle sizes of the input feed and the particular capacity of the cyclone used.

It has been found that when the input feed density is increased, the size of separation increases and the weight percent solid of both the overflow and the underflow increases. This is due primarily to the fact that with the increased density of the input material, the buoyancy force within the cyclone increases thereby forcing heavier coarse particles to the axial vicinity where they are discharged in the overflow. The particles which are too coarse are forced to the circumferential vicinity and are discharged in the underflow. The disadvantage of increasing the input feed density is that the particle size separation increases thus resulting in a particle distribution that is not as desirable as that obtainable from a lower feed density.

Inlet pressure effects the cyclone capacity and particle breakdown size, such that, by increasing the inlet pressure the capacity of the cyclone is greatly improved and the particles breakdown size is increased.

The particle size of the input feed influences the overflow and underflow solid contents, such that, by increasing the particle size of the feed, the overflow density will decrease since the coarser or larger particles, having stronger centrifugal forces, are discharged in the underflow. Thus the overflow density is decreased while the underflow density is increased.

Two present alternative methods of increasing the density of the overflow discharge is to increase the input feed density or to add a thickener to the overflow discharge. The former method results in inefficient classification in the cyclone while the latter method requires a large capital expenditure for the necessary apparatus to thicken the overflow and in some cases the material desired to be classified cannot be readily thickened.

The present invention provides an apparatus and a process for separating or classifying a liquified particle solution into two particle size components by means of employing a cyclone whereby the density of the overflow discharge, containing the finer particle sizes, can be increased without altering the density of the input feed nor adding a thickener thereto. In addition, means are provided for insuring a relatively constant input feed supply to the cyclone.

SUMMARY OF THE INVENTION

This invention relates to a process and apparatus for separating particles of a crushed or ground material by means of subjecting the material to centripetal and centrifugal forces within a substantially confined cylindrical zone such as a cyclone and then discharging the slurries from the axial and circumferential vicinities within the zone in different directions. A portion of either discharge slurry is then fed back into the zone to regulate the density of the slurry discharged from the axial vicinity to between about 25 and about 40 percent solid by weight, such slurry containing the fine fraction of particles. For example a cyclone classifier equipped with a feedback link between the overflow discharge line and the input feed line may be employed since a portion of the overflow could then be diverted back into the input feed. The feedback portion of the overflow discharge contains an average particle size smaller or less coarse than the initial feed material so that the overall mixture of the two provide an average particle size that is still less than that contained in the initial feed material. Thus for a fixed set of operating conditions, the smaller average particle size solution so formed, upon being fed into the cyclone will produce an overflow discharge having a higher density than that obtainable without the feedback fraction of the overflow being intermixed with the initial feed material. This is due to the fact that there are now more particles smaller than the "particle size separation," thus more particles are discharged into the overflow. The overflow density is thus increased without sacrificing the classification efficiency of the cyclone.

In a reverse procedure whereby the density of the overflow is to be lowered, then a portion of the underflow can be recycled back into the input feed. The average particle size in the underflow is larger than the average particle size in the input feed and an intermixing of the two will result in an input feed having more particles larger than the "particle size separation." This will result in a decrease in the density of the overflow and an increase in the density of the underflow. Thus the density of the overflow can be increased or decreased by feeding back a portion of the overflow discharge or underflow discharge, respectively.

The feedback features of the cyclone classifier may also function to preserve an adequate supply of feed

material at the input of the cyclone. This is accomplished by utilizing a level sensing means or the like in a sump that is coupled to the input feed line of the cyclone. When the level of material to be fed into the cyclone decreases in the sump to a predetermined height below which the material would be insufficient to maintain the desired flow rate into the cyclone, the level sensing means will generate a signal which can be used to regulate the flow rate of the feedback portion of the overflow and/or underflow discharge. Thus the feedback portion can be increased to heighten the level of material within the sump thereby resulting in the continuance of the desired input flow rate, such flow rate being related to the efficient operation of the cyclone.

A sample of the materials that can be classified according to this invention is scheelite, molybdenium ores, copper ores and other nonferrous or nonmetallic ores. Basically any material having various particle sizes in a liquid medium can be classified using the teaching of this invention.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic of a process for classifying or separating particles within a crushed or ground material according to the invention.

Shown in the drawing is cyclone **1** having an overflow discharge line **2,** input feed line **3** and an underflow discharge line **4.** The overflow discharge line **2** separates into discharge line **5** which feeds flotation process **6** and a second discharge line **7** whose feed is controllably regulated by valve **8** for feeding a portion of the overflow back into sump **9** via line **10.** The underflow from line **4** is separated into discharge line **19** and discharge line **20,** feed of the latter is controllably regulated by valve **13** for diverting a portion of the underflow via line **21** back into sump **9.** A liquid level sensing means **11** is assembled in such a way that it generates a signal to operate valves **8** and/or **13** via lines **22** and/or **23,** respectively, whenever the level of liquified material within sump **9** decreases below a predetermined height. Densitometer **12** is placed in the path of discharge **5** so as to measure and indicate the density thereat and it is coupled to power means (not shown) for generating a signal to operate either valve **8** or **13** via **24** or **25,** respectively, whenever the density is less than or exceeds, respectively, a predetermined set range. Crushed or ground material containing unclassified particle sizes is fed via line **14** from supply **15** into sump **9** where it is mixed with a liquid material such as water from supply **16** via line **17.** The output from sump **9** is fed via pump **18** into the input feed line **3.**

In the operational mode unclassified material is fed into the sump where it is mixed with a liquid medium, such as water, and then the mixture is pump fed at a desired flow rate into the cyclone, such flow rate depending primarily on the capacity of the cyclone employed. The unclassified mixture is then subject to centripetal and centrifugal forces within the cyclone which separates the particles of the mixture whereby the fine or smaller particles migrate to the vicinity of the central axis of the cyclone while the coarse or larger particles accumulate at the vicinity of the circumference of the cyclone. The fine particles, that is, the particles equal to or less than the "particle size separation," are then discharged into the overflow while the coarse particles, or particles equal to or greater than the "particle size separation," are discharged into the underflow. The "particle size separation" is a function of the input feed density and the feed density is an inverse function of cyclone efficiency.

The overflow discharge is fed via line **2** to a flotation process to be used accordingly. Densitometer **12** measures the density of the overflow discharge and in cases where a density range is required for a particular flotation process, and the density detected is outside of this range, then densitometer will generate a signal through conventional power means to open valve **8** or **13** depending on whether the density is below or above, respectively, this required density range. If the detected density is lower than the density required then valve **8** will be open to divert a portion of the overflow back into the sump. This will decrease the average particle size in the sump and by maintaining constant pressure and flow rate at the input, the density of the overflow will be increased. This feedback process negates the need for increasing the input density of the feed and the need for adding a thickener to the overflow when the density of the overflow has to be increased.

In a similar manner when the density detected at the overflow is above a preset range then a signal will be generated by densitometer **12** to operate valve **13** so as to divert a portion of the underflow back to sump **9.** This will increase the average particle size within the sump and thereby decrease the density of the overflow while increasing the density of the underflow. Thus an automatic system for maintaining a substantially constant overflow density is attained.

To maintain a constant supply of material in sump **9,** level sensing means **11** is employed to activate a signal to operate valves **8** and/or **13** whenever the level in the sump decreases to a height below which it will be insufficient to supply sump pump **18** with the quantity necessary to maintain the desired pressure and flow rate at the input feed. The valves will divert a portion of the overflow and/or underflow into the sump thus maintaining a level within the sump to ensure proper flow rate of the input feed. If the density of the overflow varies during the operation of valves **8** and/or **13** by the level sensing means **11,** then the signal generated by the densitometer will add to further open either valve **8** or **13** so as to regulate the density of the overflow to the range desired during this period.

It should be noted that the level sensing means or the densitometer can be used independent of each other if desired and where the densitometer is used it may be advantageous to use only one of the valves for diverting a portion of the overflow or underflow back to the input feed line.

It is also possible to add individual cyclones in parallel or series so as to accommodate a larger capacity for classifying material having various particle sizes. In addition, a portion of the overflow from a first cyclone may be diverted to the input feed of a second connected cyclone so as to control the density overflow of the latter since its density overflow is a function of the size analysis of its input feed independent on how it is obtained.

EXAMPLE

A 10 inch cyclone was used for the classification of scheelite (calcium tungstate) which was in turn required for use in a flotation process. The flotation feed density required for the flotation process was about 34 percent solid by weight so that the flotation retention time of the process could be held for about 9 minutes. The input pressure of the cyclone was fixed at 5 psig. so as to maintain an input feed flow rate of 1,800 gallons per minute for the unclassified scheelite mixed with water, such scheelite being obtained from a conventional grinding mill. A measurement of the overflow was taken to ascertain its density and was found to be 30 percent solid by weight which was lower than the density required for the flotation process. A portion of the overflow, specifically about 35 percent, was diverted back into the input feed of the cyclone and a second density reading at the overflow discharge indicated a density of 35 percent solid by weight. By regulating the feedback portion of the overflow to between about 30 and 35 percent, the density of the overflow was maintained about 34 percent solids by weight which was required for the flotation process. The density of the overflow was thus increased and maintained at a set range without increasing the density of the scheelite-containing mixture and without the need for adding a thickener to the overflow discharge.

The foregoing example is merely illustrative of the invention and a wide variety of modifications of the invention are possible as can be seen by the appended claims.

What is claimed is:

1. A process for separating the particles within a slurry into a particulated fine particle slurry having a predesired density range and a particulated coarse particle slurry comprising the steps of:

a. feeding at a substantially constant flow rate from an input supply the particle-containing slurry into a cyclone wherein the fine particles in the slurry migrate to the central axis of the cyclone while the coarse particles in the slurry migrate to the circumference of the cyclone;

b. discharging the fine particle slurry in one direction;

c. discharging the coarse particle slurry in a direction that does not coincide with the direction in step b;

d. detecting the density in the fine particle slurry overflow; and

e. diverting a portion of the discharge slurry from at least one of the steps (b) and (c) back into the input supply for as long as the density of the discharging fine particle slurry falls outside of a predesired range.

2. The process as in claim **1** wherein in step (e) the predesired density range of the fine particle slurry is between about 25 percent and about 40 percent solid by weight.

3. The process as in claim **1** wherein after step e. the following step is added:

f. diverting a portion of the discharging slurry from at least one of the steps (b) and (c) back into the input supply when the level of the slurry within the input supply falls below a level necessary for substantially maintaining a constant flow rate of the slurry into the cyclone.

4. The process as in claim **1** wherein the material to be classified is selected from a group consisting of scheelite, molybdenium ores, and copper ores.

5. The process as in claim **1** wherein the material to be classified in the cyclone is scheelite and the density range of the fine particle slurry is between about 30 and 35 percent.

6. An apparatus for separating particles within a liquified medium comprising a cyclone having an input feed line from a supply sump, an overflow discharge line and an underflow discharge line, the improvement which comprises at least one feedback link between the overflow and underflow discharge lines and the input feed line, said feedback line having a signal operated valve means; densitometer means positioned in the overflow discharge line and being capable of generating a signal whenever the detected density of the overflow discharge deviates from an adjustable predetermined range setting; and means for feeding said signal from said densitometer means to the valve means so as to operate said valve means and thereby divert a portion of the discharge back into the input feed line whenever the measured density in the overflow discharge line deviates from a predesired range.

7. An apparatus for separating particles within a liquified medium comprising a cyclone having an input feed line from a supply sump, an overflow discharge line and an underflow discharge line, the improvement which comprises at least one feedback link between the overflow and underflow discharge lines and the input supply sump; liquid level sensing means positioned in the input supply sump, said liquid level sensing means capable of generating a signal when the level of the slurry in the input supply sump decreases below a predetermined level; valve means assembled in at least one of the discharge feedback lines; means for feeding said signal from the liquid level sensing means to said valve means so as to operate said valve means to divert a portion of the flow of at least one of the discharge lines back into the input sump whenever the height of the slurry in the input supply sump decreases below a predetermined level that is required for maintaining a constant input feed flow into the cyclone; densitometer means positioned in the overflow discharge line and being capable of generating a signal whenever the detected density of the overflow discharge deviates from an adjustable predetermined range setting; and means for feeding said signal from said densitometer means to the valve means so as to operate said valve means and thereby deviate a portion of the discharge flow at least one discharge line back into the input supply sump whenever the measured density in the overflow discharge line deviates from a pre-set range.

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