ABSTRACT: Control apparatus actuates a skimmer for removing accumulated heavy-phase material on the peripheral wall of a centrifuge bowl by supplying pressurized control liquid to an inwardly facing annular pocket. The latter is mounted for rotation with the centrifuge bowl and provided with a drain passageway leading outwardly and having an outer outlet which is obstructed by accumulated heavy phase material, whereby back pressure in the supply line for the control liquid initiates operation of the control.
CONTROL APPARATUS FOR CENTRIFUGE

This application discloses a modification of the subject matter of application Ser. No. 745,945, filed July 18, 1968 in the name of William J. Kirkpatrick as a continuation of his U.S. Pat. No. 3,407,999, which issued Oct. 29, 1968, both assigned to the assignee of the present invention.

This invention relates to control apparatus for centrifuges operated on a cyclical-sludge-discharge basis, and more particularly to automatic means for detecting or sensing the extent of sludge buildup and for initiating removal of the accumulated sludge from the bowl by suitable discharging means.

In the solid bowl cyclcical-sludge-discharge centrifuges of the prior art, feed has been delivered into the bowl preferably at one end and the clear effluent has discharged over a lip at the other end. In perforated bowl or basket machines, however, the effluent discharges outwardly through perforations in the bowl wall. With either type of machine sludge has built up a cake against the bowl wall. After a set period of time, according to prior practice, based on experience and approximating the time required for sludge to build up to the maximum level before it appears in the effluent, the feed has been shut off for a time. Thus, a timer has previously actuated the sludge removal equipment, usually a skimmer which initially leads the clarified liquid to discharge. Subsequently, as the skimmer reaches the sludge cake an operator, seeing the sludge in the skimmer discharge, diverts it to waste. When sludge has been removed from the bowl to the extent practicable, the skimmer is returned to its inward rest position and feed to the bowl is resumed.

The manual or semiautomatic processes of the prior art as described above has had severe disadvantages. Obviously sludge buildup rates vary even with the same slurry feed rate. The timed actuation as described takes no account of this. As a result, process time may be lost in too frequent unloadings or, worse, the unloadings on occasion will not be frequent enough and sludge will appear in the clarified liquid. Furthermore, if an operator does not detect early traces of sludge in the skimmer discharge, the effluent becomes contaminated with an objectionable amount of sludge. Besides this, there is the objection to the need for any full-time operator to give the operation of the centrifuge his full attention, a complaint which becomes increasingly significant with increasing labor costs.

There have thus been attempts to provide a completely automatic sludge dumping cycle in a centrifuge of the type described. Some older detectors of sludge in the effluent have been based on the optical opacity of the discharging effluent and have employed electric eye means or equivalent. These have been fallible because the area in which such machines are disposed is often not clean and the lenses of such detectors have become clouded giving false indications of opacity.

With the present invention there is provided an extremely simple and virtually foolproof means for detecting the sludge level in a solid bowl centrifuge and for actuating the sludge discharge mechanism. The present arrangement provides for the actuation of the sludge discharge cycle when and as necessary but before sludge is actually present in the effluent, thereby avoiding any escape of solids into the clarified liquid. This is in contrast to the optical opacity and density means which indeed did not even commence to function until the effluent become clouded with sludge.

Other objects of the invention will be clear from a reading of the following specification including the drawings in which:

FIG. 1 is a sectional view of a centrifuge embodying the invention and showing in schematic form some of the controls thereof;

FIG. 2 is an enlarged fragmentary sectional view of the centrifuge of FIG. 1, taken along line 2-2 thereof;

FIG. 3 is an enlarged fragmentary sectional view, taken along line 3-3 of FIG. 2; and

FIG. 4 is a fragmentary view of FIG. 1 showing a modified peripheral wall of the centrifuge bowl, with perforations.

Briefly, the invention involves pressure-responsive, automatic sludge discharge arrangement for a cyclically unloading centrifuge. The dumping cycle is actuated upon the sludge in the bowl to a certain level, as indicated by a buildup of back pressure in a line supplying control liquid, and thereafter the feed is discontinued, the dumping of the sludge is automatically efficiently accomplished, and the feed is resumed.

Recording more specifically to the drawings, an arrangement embodying the invention is indicated in FIG. 1 and the apparatus is generally designated 10. It comprises a base 12 having a plurality of upstanding standards 14, only one of which is shown. Suspension means 16 attached to the standards 14 hang the centrifuge bowl housing 18. At the lower end of the housing is a bearing 20. The centrifuge bowl 22 is mounted on a shaft which passes through the bearing and mounts on its lower end a pulley 24. The pulley is driven by belt means 25 from the motor 26.

The bowl 22 presents an imperforate bottom wall 28 and peripheral wall 30. The upper end wall 31 is likewise imperforate and provides a discharge lip 32. More or less axial and radial vanes (not shown) may be provided in the bowl 22 at its periphery.

Feed slurry is introduced to the bowl 22 through a feed tube 34 stationarily mounted over the bowl. The feed slurry comprises a forward mixture of at least two materials wherein one material has a higher specific gravity than the other material and thus tends to build up on the periphery of the bowl 22. The tube 34 is provided with a valve 36 operated by a solenoid 38. A feed-receiving cup 40 is mounted on the top of the bowl hub and rotates with the bowl 22. From the cup 40 a plurality of feed conduits 42 extend longitudinally of the bowl down to the bowl bottom. The ends of the conduits 42 have openings and pass the feed slurry into the bowl 22 with little turbulence.

Connected to the lower end of the centrifuge bowl housing 18 is the effluent outlet conduit 44. This leads the conduit to an effluent tank 46 from which the product effluent is drawn.

For removing the sludge in the cyclcical operation the centrifuge is provided with a skimming device 50. This includes a tube 51 of substantially J-shaped which presents an open mouth 52 facing the direction of rotation of the bowl 22. The skimmer is mounted on the housing 18 in a plurality of bosses 54 in which the skimmer device is longitudinally movable. As in the past the basic operation of the skimmer 50 is similar to other skimmers. As the skimmer 50 is moved out or deeper into the bowl 22, a combination of the velocity of the liquid passing into the stationary skimmer mouth 52 and the centrifugal pressure head of the liquid in which the skimmer 50 is submerged causes the liquid to be "pumped" into and through the skimmer device.

Means for driving the skimmer device are indicated schematically at 56. These means may comprise a pair of pneumatic piston-cylinder assemblies which drive the skimmer alternately forward and back respectively. The drive means 56 is carefully arranged so that at one inward extreme of travel the skimmer is disposed with its mouth 52 out of the liquid in the bowl 22 and inward of the lip 32. At the other or outward end of its travel the skimmer mouth 52 has an extreme of roughly one-fourth inch from the peripheral wall 57 of the bowl 22 so that it can remove nearly all of the sludge settled against the peripheral wall 57 of the bowl. Limit switches, valves, or other devices assure the ends of travel and may be incorporated with the bosses 54 to effect reversal of the drive means 56.

Attention is now directed to an essential portion of the invention. Mounted outside the bowl 22 on annularly spaced ribs 58, in turn secured to the upper end wall 31, is the control liquid ring 60. The ring 60 is, of course, annular and is channel shaped in cross section as shown in the drawing. The ring 60 may be welded or otherwise attached with the ribs 58 to the top wall 31 of bowl 22 in coaxial relationship therewith; and is very preferably arranged so that the "floor" of the channel section is at the same radial level as the effluent discharge lip.
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32 of the centrifuge if the peripheral bowl wall 57 is imperforate. As shown, the ring 60 is formed about the rotational axis to extend outwardly and axially downward, terminating outwardly of the lip 32 of the maximum desired sludge level A of the bowl 22. The outer end of the tube 62 has a restricted outlet 63 to assure proper obstruction of the opening in plate 66 by sludge as the sludge builds up inward. The position of the outer end of the tube 62 will determine the level to which sludge buildup is permitted before the sludge-unloading cycle commences.

Referencing once more to FIG. 1 the effluent tank 46 has connected to it a liquid line 64 which may lead to a pump (not shown). If desired, the line 64 may further extend, as by broken line 65, to the top of the centrifuge housing 18 to provide the control liquid. As shown, however, it is optional that a separate feed line 66 from a source of pressurized liquid, e.g., water, provides the control liquid. Line 66 carries the control liquid through a flow control valve 67, a pressure-responsive switch 68, and thence through a discharge nozzle 69 positioned as shown well into the pocket of ring 60 with clearance therebetween. Depending on the economics of the process and other factors this control liquid feed line 66 which discharges at a very low rate, for instance, one-half gallon per minute, may run continuously or may be shut off with the feed through pipe 34. The control liquid preferably has a lower specific gravity than that of the accumulated solids, and preferably is the same material as the effluent.

The pressure-responsive solenoid switch 68 is set to be open at a certain pressure of the control liquid fed through line 66, adjustably maintained at a predetermined setting by flow control valve 67 so long as the drain tubes 64 remain unobstructed to permit emptying of the ring 60. However, when sludge builds up to the level A the outlet 63 of tubes 64 are obstructed and the level of control liquid in ring 60 builds up inwardly to immerse the nozzles 69 and thereby resist discharge of control liquid from the nozzles 69. Such resistance immediately creates a back pressure in the feed line 66, which back pressure is detected by the pressure-responsive switch 68. A predetermined increase in pressure detected by switch 68 actuates the closing thereof and initiates the closing of the feed tube 34 and the driving means 56 for the skimmer 50.

When it is desired to change the maximum desired sludge level L to a lower level, so that when the limit switch 82 is tripped in reverse direction to normal position wherein the flow from the skimmer tube 51 is again directed to the effluent collection container, e.g., tank 46. The operation of the device described herein commences with the bowl 22 rotating, and with feed being delivered to the bowl through the normally open valve 36 in feed tube 34. Control liquid is also being delivered at regulated pressure through the line 66 to the ring 60 and passes out through each of the open sludge-level-sensing tubes 62. In a solid bowl machine having an imperforate wall 57 the clear effluent flows over the lip 32, thence through the spaces between the ribs 58, and is thrown outward and passes down the inside wall of the housing 18 and moves out through the effluent discharge conduit 44 to the effluent tank 46. The sludge of the feed slurry gradually builds up against the peripheral wall 57 of the bowl 22. During this time the mouth 52 of skimmer tube 51 is located inwardly of the overflow lip 32.

When the sludge builds up to the outer end of the sludge-level-detecting nozzle 62 and eventually reaches level A therein it covers the restricted outlet 63. This blocks the further escape of control liquid from the ring 60 and liquid builds up within the ring. When the liquid is built up in the ring 60 to the extent where the increased pressure in line 66 downstream of flow control valve 67 is sufficiently influenced thereby, the switch 68 is closed. The closing of switch 68 electrically energizes the solenoid 38 and closes the solenoid-operated diverting valve 84 which also actuates the skimmer drive means 56 to drive the skimmer to the rightward as shown in FIG. 1 causing the mouth 52 of the outwardly moving skimmer to engage the liquid in the bowl. This liquid is "pumped" out by the action of the skimmer and is sent to the clarified effluent discharge. When the skimmer drive means 56 moves the skimmer 50 far enough to the right, however, the lug 80 engages the switch which actuates the solenoid-operated diversional valve 84 to divert the outflow from the skimmer to waste. The position of the limit switch 82 is such that this will be just before the mouth 52 of the skimmer 50 reaches the level A of sludge buildup—or approximately the level of the outermost end of the tube 62—so that all sludge is diverted to waste with none moving out to the clarified liquid discharge.

The skimmer drive means 56 drives the skimmer on to its outer limit of travel. As already indicated the proper limit is when the mouth 52 of the skimmer reaches a point about one-quarter inch, more or less, from the inner face of wall 57 of the bowl. The skimmer drive means 56 then reverses the travel of the skimmer. When the position of the skimmer is such on its leftward travel (FIG. 1) that the lug 80 engages the limit switch 82, the switch 82 will cause the solenoid-operated diversional valve 84 to divert the outflow from the skimmer back to the effluent. By this time, however, no material is passing through the skimmer and the skimmer discharge flow is "reset" so to speak for its next cycle of operation. When the skimmer reaches its leftward position inward of lip 32, the skimmer drive means 56 reverses itself, ready for the cycle of operation, and stops, simultaneously deenergizing the solenoid 38 to open the feed valve 36 for the start of another cycle. Likewise, if the optional shutoff feature is incorporated in valve 67 this too is deenergized to resume flow of control liquid through line 66 for the start of another cycle.

It will be apparent that once the sludge has been removed from the bowl by the skimmer 50, centrifugal force throws any adhering sludge away from the restricted outlet 63 at the outer end of each tube 62. The tubes 62 are thereby unobstructed and control liquid flows therethrough and does not accumulate in the ring 60 until subsequent sludge build up.

It will be clear from the above description that the centrifuge embodying the invention is completely automatic in operation and operates on a sludge-level-sensing basis rather than on a time basis. The time basis is fallible since the amount of solids in a given feed slurry may vary from time to time. Also it is clear that the present invention provides positive automatic means for precluding the passage of sludge into the clarified liquid effluent and does not rely on the presence of
sludge in the effluent for actuation. The present device is simple and virtually foolproof. Once it is set into initial operation it requires no operator.

Obviously variations of the invention are possible. For instance, the peripheral bowl wall 57 may be perforated as in FIG. 4 to permit the flow of effluent therethrough while retaining the solids, rather than discharging effluent over the overflow lip 32. Furthermore, the electrical and fluid flow arrangements may be varied as well. For instance, it has been discussed that the valve 67 may optionally control flow of control liquid during sludge discharge, and skimmer drive means 56 may come from a wide range of motor means, electrical pneumatic, or hydraulic for example.

A variation of the present invention is the provision of a skimmer-type sensing tube, constructed and arranged similar to the feed tube 66 of the drawings but in addition thereto, whereby a buildup of control liquid in the ring 60 forces liquid into the mouth of the skimmer tube facing opposite to the direction of bowl rotation and builds up pressure for closing a pressure switch, instead of like switch 68 for initiating dumping of sludge as aforesaid.

In the case described the effluent has been the valued discharge and the sludge has been simply waste. It should be understood, however, that the invention is applicable to processes where the solid phase is of value and accordingly it is disposed to an appropriate container "containing" solids as herein included any solids or any material which has a higher specific gravity than another material in the same feed mixture.

Furthermore, although the invention has been described with reference to a preferred pressure-responsive switch 68 in the feed line 66, it is not so limited. The invention may be practiced by employing other kinds of sensing means responsive to a change in at least one of the various flow characteristics of the control liquid in the feed line 66, including velocity and flow rate as well as pressure, for actuating the means for discharging accumulations, e.g., solids, from the bowl. If the sensing means 68 is velocity responsive it will respond to a decrease in velocity of the control liquid in feed line 66. If the sensing means is responsive to flow rate of control liquid in the feed line 66 it will respond to a decrease in flow rate.

As a further modification small adjustments in responsiveness to solids buildup can be made while the machine is rotating by setting the pressure switch 68 to react to a greater or reduced pressure increase. With this arrangement, a greater pressure increase provides for reaction to a greater solids accumulation, and vice versa.

A still further modification contemplated by the present invention is radial adjustment of the nozzle 69 of the feed line 66 within the ring 60, also possible without shutting down the machine. An adjustment toward a radial inward position delays the reaction of the sensing means 68 and therefore produces a larger solids accumulation before actuation of discharge, and again vice versa.

Where the bowl 22 has a perforated wall 57 the skimmer tube 51 may be omitted. Instead a radially movable knife or peeler may be substituted to discharge accumulated solids. However, this is not shown or described since the present invention is primarily directed to control apparatus in a centrifuge having any kind of device for discharging separated materials.

The present invention may thus be embodied in other specific forms without departing from the spirit or central attributes thereof and, accordingly, reference should be made to the appended claims rather than the foregoing specification as indicating the scope of the invention.

What I claim is:

1. A centrifuge including a rotatably mounted, centrifuge bowl having means for feeding into the bowl a flowable mixture of at least two materials wherein one material has a higher specific gravity than the other material and after centrifugal separation one material builds up against the peripheral wall of the bowl, means for discharging accumulations of said one material, means for continuously discharging the other material, and means for detecting the accumulation of said one material to predetermined level, said detecting means comprising structure defining an inwardly facing annular pocket mounted to rotate with the bowl, a passageway leading outwardly from the pocket generally toward the periphery of the bowl and terminating with an outermost opening of the passageway within the bowl outward of the annular pocket, means to supply a control liquid to the pocket, and sensing means to sense the buildup of control liquid in the pocket whereby when said material reaches a predetermined level and obstructs said pocket opening the control liquid builds up in the pocket, said sensing means being responsive to a change in at least one of the flow characteristics including pressure, velocity and flow rate of said control liquid for actuating the means for discharging accumulations of said one material from the bowl.

2. A centrifuge according to claim 1 wherein said sensing means is a pressure-responsive switch in said supply means responsive to an increase in pressure of said control liquid.

3. A centrifuge according to claim 1 wherein said sensing means is a flow-responsive switch in said supply means responsive to a decrease in flow of said control liquid.

4. A centrifuge according to claim 1 wherein said sensing means is a velocity-responsive switch in said supply means responsive to a decrease in velocity of said control liquid.

5. A centrifuge according to claim 1 wherein the supply means for the control liquid is tubular and has a discharge outlet disposed entirely within the pocket adapted to be immersed in accumulated control liquid within said pocket when the outermost opening of the passageway leading therefrom is obstructed by an accumulation of said one material.

6. A centrifuge according to claim 5 wherein the sensing means is a pressure-responsive switch in the supply means for the control liquid, which switch detects an increase in pressure in the tubular supply means resulting from the back pressure caused by the immersion of said discharge outlet in accumulated control liquid within said pocket.

7. A centrifuge according to claim 6 further including means for regulating the pressure of the control liquid in said supply means upstream of said switch.

8. A centrifuge according to claim 1 wherein the sensing means discontinues the flow of feed during removal of an accumulation of said one material from the bowl.

9. A centrifuge as described in claim 1 wherein the sensing means discontinues the flow of control liquid during removal of an accumulation of said one material from the bowl.

10. A centrifuge according to claim 1 wherein the centrifuge bowl is of imperforate construction with an overflow lip at one end thereof comprising said means for continuously discharging the other material.

11. A centrifuge according to claim 10 wherein the inner surface of the pocket is disposed at the radial level of said lip.

12. A centrifuge according to claim 1 wherein the structure defining the pocket is secured to the outside of the centrifuge bowl in coaxial relationship therewith.

13. A centrifuge according to claim 1 wherein the centrifuge bowl is perforated, the perforations defining the means for discharging the other material from said bowl.

14. A centrifuge according to claim 1 wherein the means for discharging accumulations of said one material is a skimmer tube within said bowl movable in radial direction relative to the rotational axis of said bowl.

15. A centrifuge according to claim 14 further including a device for discharging material through said skimmer tube in one direction of flow during a first portion of outward radial movement of said tube and then in a second direction of flow during a second portion of outward radial movement of said tube, whereby said one material and said other material are separately discharged in the respective first and second directions of flow.