ABSTRACT: A sedimentation tank of the type wherein the rake arms of a rotary rake structure are linked to a central vertical member such as a vertical shaft or cage, with inclined draft or drag elements connecting them to respective drive arms spaced upwardly from the rake arms and fixed to the vertical member. Improved feedwell means are structurally combined with the drive arms, comprising an auxiliary feedwell at an upper level, and a main feedwell at a lower level receiving from said upper level streams of feed pulp directed into annular countercurrent paths located one above the other, in such a manner that the influent energy is dissipated, and the feed pulp is distributed radially evenly in all directions, as it enters the surrounding body of liquid undergoing sedimentation.
This invention relates to continuously operating sedimentation tanks wherein the settled solids or sludge are continuously removed from the tank bottom by means of a rotary rake structure conveying the sludge to a central sump for withdrawal, while the solids suspension or feed pulp is centrally supplied through a suitable feedwell arrangement, while separated liquid may overflow from the periphery of the tank.

The sedimentation tanks, for the purposes of this invention, may be of the type wherein the rake structure is operatively supported from an overhead construction or bridge spanning the tank, or else the rake structure may be supported by, and revolve around a center pier rising from the bottom of the tank.

In the bridge-supported rake structure a vertical depending rake shaft with its rake arms is rotatably supported from a drive head for rotation about a vertical axis, the drive head in turn being mounted on the bridge. In the pier-supported type, the rake arms extend from a central vertical cage portion of the rake structure, which cage portion surrounds the pier and is rotatably supported from the drive head mounted atop the pier.

More particularly, this invention is concerned with improvements in sedimentation apparatus or tanks of a type such as represented in the U.S. Pat. to Klopper, No. 3,295,835 of Jan. 3, 1967. In a distinction from the more conventional rotary rake structures the Klopper type machine employs separate drive arms which have draft elements or ropes connecting them to what are light weight simple straight tubular rake arms which in turn are linked to the vertical shaft of the rake structure.

By thus applying a balanced drive torque to the rake arms indirectly, that is to say from the drive arms through the draft elements, the Klopper machine avoids having complex or bulky girder arm structures operate in a sludge thickening zone and under direct heavy load, exposed to scaling and island formation. These adverse conditions heretofore have not only necessitated frequent shutdowns for cleaning purposes, but they also have added greatly to the weight that must be supported by the bearing means of the rotating rake structure, while also adding to the amount of operating torque required. These troublesome conditions are encountered for instance in the handling of heavy metallurgical sludges, and particularly they are troublesome in the thickening of the heavy viscous red mud in the alumina industry. However, in the Klopper machine the aforementioned light weight simple straight tubular rake arms have been found to be largely immune to the above adverse conditions so that the periods between shutdowns and overhauls have been greatly increased, for example from several weeks heretofore required with conventional girder type rake arm structures, to periods of one to two years of uninterrupted operation.

This invention is concerned more particularly with improving the manner of introduction of the feed pulp into the Klopper machine, in view of problems due to the presence of the drive arm structure.

The object is to introduce into the feedwell a pair of streams directed into annular countercurrent paths located one above the other, in such a manner that the influent energy is dissipated or diffused, and the feed pulp is distributed radially evenly in all directions, while entering the surrounding body of liquid undergoing sedimentation.

In one preferred embodiment, the invention utilizes a feedwell unit substantially of the type disclosed in U.S. Pat. No. 3,404,474 to Fitch.

This type of feedwell unit rapidly and completely dissipates the kinetic energy of a liquid stream or feed liquid entering a thickener or clarifier, into random turbulence of small scale eddies before entering the quiescent body of liquid undergoing sedimentation in the tank.

In this feedwell annular race ways of inwardly open annular channels are juxtaposed one above the other within a feedwell cylinder. The main stream of the feed liquid is split into separate streams which are fed into these annular channels tangentially as well as counter currently relative to each other, so that one stream rotates clockwise and the other counter clockwise, around the vertical axis of rotation of the rake structure. These mutually opposed rotating streams are displaced inwardly into the open area surrounded by the channels, and are compelled to shear along the entire length of these channels at twice the velocity of either stream. The stream velocities entering the feedwell are thereby instantaneously converted to random turbulence, and if the streams are made equal but oppositely directed, there are no residual tangential velocity components, so that a uniform flow velocity is obtainable across the area of the resulting stream passing from the feedwell radially outwardly in all directions into the quiescent body of liquid in the tank. This mode of feed introduction improves the overall sedimentation efficiency of the tank.

However, the drive arm structure in the Klopper machine especially when located above the liquid level to avoid scale formation on the arms, creates a problem in respect to placing or mounting the aforementioned energy/dispensing type feedwell unit in such a manner that it may operate effectively concentric with the vertical axis of rotation of the rake structure. For example, it is unfeasible to connect the aforementioned type of feedwell unit submersible drive arms to rotate therewith, although that position would place the feedwell in suitable operative submergence while allowing for unobstructed delivery of the feed pulp into the surrounding body of liquid in the tank. Yet, a stationary horizontal feed supply pipe or conduit leading into the feedwell would interfere with the rotating parts such as the aforementioned draft elements of the rake structure.

On the other hand, mounting the Fitch type feedwell unit on top or above the drive arm structure in order to bring it within the reach of the stationary feed supply conduit would require the drive arms to be lowered to an even lower level of submergence, in order to have this feedwell operate properly submerged below the liquid level in the tank. Again, if the drive arms were located above the liquid level, this would raise the feedwell on top of it to an elevated emerged and therefore inoperative position.

In order to solve the problem of contradictory alternatives, this invention provides a feedwell arrangement combined and unitary with the rotating rake structure, featuring an exposed auxiliary feedwell located at an upper level, and a submerged feedwell located at a lower level, and receiving countercurrent streams of feed pulp from the upper level. The rotating auxiliary feedwell in turn receives the feed pulp from a stationary duct. The preferred energy dispersing type feedwell unit herein also termed the main feedwell may then be connected to, or integrated into the drive arm structure so as to be located below said auxiliary annular feedwell, both the auxiliary feedwell and the main feedwell thus becoming unitary with the rotary rake structure. Feed transfer duct or passage means supply the feed pulp from the auxiliary feedwell to the annular inwardly open channels of the main feedwell, in such a manner as to maintain the two streams in the desired countercurrent energy dissipating annular paths.

When embodied in the structural arrangement according to this invention, the desired type feedwell may be used effectively irrespective of the presence and the position of the drive arm structure.

The two countercurrent streams may be introduced by way of elbow-shaped pipes located internally of the main feedwell, or else by way of external piping connected tangentially to the main feedwell cylinder.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiments are illustrative and not restrictive. The scope of the invention is defined by the appended claims rather than by the description preceding them, and all embodiments which fall within the meaning and range of
equivalency of the claims are therefore intended to be embraced by those claims.

FIG. 1 is a vertical, sectional view of a sedimentation tank having a rotary rake structure embodying one form of the feedwell construction of this invention, which has an auxiliary feedwell at an upper lever communicating with a main feedwell at a lower lever.

FIG. 16 is an enlarged view of details of the rake structure taken from FIG. 1.

FIG. 18 is a top view taken on line 18b in FIG. 1a.

FIG. 2 is an enlarged view of the feedwell construction taken from FIG. 1.

FIG. 5 is a cross section taken on line 5-5 in FIG. 2.

FIG. 15 is a vertical, sectional view of the central portion of a rotary rake structure, showing a modified feedwell construction of this invention, differing from FIG. 2.

FIG. 7 is a cross section taken on line 7-7 of FIG. 6.

FIGS. 8, 9 and 10 are diagrammatic renditions of the feedwell construction of FIG. 2, showing various modifications.

FIG. 11 is a diagrammatic rendition of the feedwell construction showing still another modification.

FIG. 12 is a plan view taken on line 12-12 in FIG. 11.

The sedimentation apparatus in the embodiment in FIGS. 1 to 5 is equipped with a rake structure 10 operating in a tank 11, and supported from an overhead structure or bridge 12 extending diametrically across the tank. Feed slurry or pulp is supplied to the tank through a feed supply pipe 13, while clarified liquor overflows into a peripheral launder 14, and sediment or sludge is conveyed by the rake structure over the tank bottom through a central collecting zone or sump 15 for withdrawal through a sludge discharge pipe 16.

The rake structure itself comprises a vertical shaft 17 depending from and rotated by a drive mechanism 18 mounted upon the bridge.

A pair of rake arms 19 and 20 are connected to the lower end portion of the shaft by means of a double bracket D, in such a manner as to be movable about a horizontal axis h-h, as well as about a vertical axis V-V (see also FIGS. 1a and 1b).

The rake arms themselves are in the form of tubular members 19a and 20a respectively, to which are welded the usual raking blades 19b and 20b respectively.

A pair of horizontal drive arms 21 and 22 is fixed to the upper portion of the shaft, so as to extend just above the overflow level L. Each drive arm pulls an associated rake arm against a sludge load on the bottom of the tank, through inclined draft elements or drag rope means 23 and 24 respectively. It will be seen that rotation of the shaft by the drive mechanism will cause the rake arms to move sludge over the tank bottom to the central collecting zone, while leaving them free to yield to undue sludge accumulations, by a compound movement about the horizontal and vertical axes.

A feed suspension or slurry or a pulp is supplied through feed pipe 13 to a feedwell construction 25 which according to the invention comprises an upper or auxiliary feedwell 26, and a lower or main feedwell 27, both built substantially concentric around the axis of rotation of the rake structure, although in this embodiment vertically spaced from each other by the drive arm structure.

In this embodiment, the auxiliary feedwell is in the form of an annular trough fixed to the top side of the drive arm structure, while the main feedwell comprising a cylinder 28 is fixed to the underside. Feed slurry received by the annular feedwell trough 26 is delivered into the main feedwell 27 through a pair of depending ducts or transfer pipes 29 and 29a terminating within the feedwell cylinder 27. The shorter transfer pipe 29 of length 1-1 has an elbow shaped lower end portion directed for delivering a first stream of feed slurry substantially tangentially into an upper annular horizontal zone Z-1 of the main feedwell. The longer transfer pipe 29a of length 1-2 also has an elbow shaped lower end portion directed for delivering a second stream of feed slurry substantially tangentially into an annular horizontal zone Z-2 of the main feedwell. These two annular streams are directed opposite to one another, operating in submergence, that is below the liquid level L.

Furthermore, according to FIG. 2, the lower zone Z-2 may be confined between an annular bottom shelf 30 and an intermediate shelf 31. The upper zone Z-1 may be confined between the intermediate annular shelf 31 and an annular top shelf or plate 32. The two countercurrently rotating streams are subject to mutual shearing action in the central area surrounded by the zones Z-1 and Z-2, with the result that the influent energy is dissipated, and the feed slurry enters the surrounding quiescent body of liquid uniformly distributed in all directions as indicated by arrows A.

Referring again to FIG. 2, although the upper auxiliary feedwell and the lower main feedwell are shown to have the same outside diameter, it should be understood that, as to construction and dimensioning, the one is substantially independent of the other, governed only by the basic underlying concept of this invention, as will be furthermore exemplified below.

In the embodiment of FIGS. 6 and 7, the rake structure has a shaft 33 depending from, and supported by a drive unit 34 mounted upon a bridge structure indicated at 35. A pair of rake arms 37 and 38 are similar to those above in FIG. 1, including the manner in which they are connected to the shaft, allowing each rake arm to be movable about a horizontal and a vertical axis. However, a pair of drive arms 39 and 40 associated with respective rake arms through draft elements or drag ropes (here not shown), is substantially submerged just below the liquid level L-2 in the tank, in order that a low roof structure 41 for the tank may be accommodated.

The drive arms are of girder type construction having a pair of parallel upper stringers 42 and 43 shown to be composed of angle-connected pipe sections, and a similar pair of parallel lower stringers 44 and 45, all stringers being interconnected by bracing members at the sides, the bottom, and the top. This constitutes a substantially square cross-sectional profile of the girder, having a width w (see FIG. 7) and a height h (see FIG. 6). The middle portion of the girder intermediate the ends is fixed to the shaft of the rake structure. Thus, the upper pair of stringers are rigidly welded to each other and to the shaft by means of an upper horizontal gusset plate 46 of square configuration. A similar lower gusset plate 47 similarly interconnects the lower pair of stringers and the shaft.

The feedwell structure of FIGS. 6 and 7, while functionally similar to the one in FIG. 1, has a main feedwell 49 integrated integral, or horizontally penetrated by the drive arm girder structure just described, while an associated auxiliary feedwell 50 surrounding the shaft is fixed to the top side of the girder. In this way, the upper auxiliary and the lower main feedwell are joined together substantially at the liquid level L-2, with the main feedwell properly positioned and submerged in the top zone of the liquid body in the tank.

A cylinder 51 of the main feedwell has inner annular shelves 52 and 53 defining a lower annular zone Z-4, and has an annular top plate 54 defining with shelf 53 an upper annular zone Z-5, the top plate also constituting the bottom of auxiliary feedwell 50.

A pair of depending feed transfer pipes 55 and 56, substantially in the manner of the FIG. 1 embodiment, supply countercurrently directed streams of feed slurry from the upper or auxiliary feedwell tangentially into respective annular zones Z-4 and Z-5. In this way, the influent energy is dissipated in the manner previously described, allowing the feed slurry to enter the surrounding body of quiescent liquid uniformly distributed in all directions as indicated by arrows B.

FIGS. 8, 9 and 10 while rotating with the FIGS. 1 to 5 embodiment, are diagrammatic renditions illustrating some of the modifications that come within the concept of the combination of the drive arms with an annular auxiliary feedwell located at an upper level, and a main feedwell located at a lower level, both feedwells rotating unitary with the rake structure, while streams of feed slurry are supplied from the auxiliary feedwell countercurrently and tangentially into an
upper and a lower zone within the main feedwell. The liquid level is indicated at L–3.

Accordingly, FIG. 8, while omitting the annular shelves from the cylinder of the main feedwell, shows two depending transfer pipes 57 and 58 delivering streams of the feed slurry countercurrently and tangentially into an upper and a lower annular zone designated at Z–6 and Z–7 respectively.

FIG. 9 adds to the FIG. 8 construction an annular bottom shelf 59 for downwardly confining the lower annular zone Z-8, the upper zone being designated as Z–9.

FIG. 10 adds to the bottom shelf 59 of the FIG. 9 construction a second annular shelf 60 spaced upwardly to provide an annular partition between the lower zone Z–10 and the upper zone Z–11.

Another modification shown in FIGS. 11 and 12 differs from the preceding embodiments in that the two countercurrent streams of feed slurry are introduced into their respective upper and lower zones Z–12 and Z–13 by means of pipes 62 and 63 having their inner ends connected tangentially to the outside of a main feedwell cylinder 64, and their outer ends connected to an annular auxiliary feedwell 65 having an outside diameter substantially larger than that of the main feedwell cylinder located below.

It should be understood that the invention as herein illustrated need not be limited to the depending type of rake structure supported from an overhead construction or bridge, but that the concept is applicable also to the initially mentioned center pier-supported type of rake structure, in which case a corresponding feedwell construction is built around and connected to the vertical central cage portion of the rake structure that surrounds the pier.

1. In a continuously operating sedimentation tank having a supply of feed liquid, a bottom outlet zone for sludge and overflow means for liquid separated from the sludge, and determining the liquid level in the tank, the combination which comprises:
   a rake structure mounted for rotation about a vertical axis, effective to move sludge over the tank bottom into a sludge outlet zone, said rake structure comprising a central vertical member, bearing means at the upper end of said vertical member, supporting said member for rotation about said vertical axis, a plurality of rake arms extending from the lower end of said vertical member, a drive arm structure having a corresponding number of drive arms extending rigidly from the upper end portion of said vertical member, and draft elements connecting the outer end portions of said drive arms with said rake arms; drive means for rotating said vertical member, effective to impart drive torque through said drive arms and said draft elements to said rake arms; an auxiliary annular feedwell receiving feed liquid, in the form of an annular channel substantially concentric with said vertical axis and connected to the top side of said drive arm structure; and a main feedwell fixedly connected to said drive arms substantially concentric with said axis of rotation, and located below said auxiliary annular feedwell and in submergence, and flow passage means constructed and arranged to deliver a pair of streams from said auxiliary feedwell into said main feedwell, said streams being directed into annular countercurrent paths located one above the other, in such a manner that the influent energy is dissipated, and the feed pulp is distributed radially evenly in all directions while entering the surrounding body of liquid undergoing treatment.

2. The combination according to claim 1, wherein said main feedwell is connected to the underside of said drive arms.

3. The combination according to claim 1, wherein said main feedwell is connected to the underside of said drive arms, and said flow passage means comprise at least one pipe extending downwardly from said auxiliary feedwell through the area surrounding said annular streams.

4. The combination according to claim 1, wherein said drive arms are of girder type construction, and wherein said main feedwell is integrated into the girder structure of the drive arms with both said feedwell and said drive arms located in submergence.

5. The combination according to claim 1, wherein said drive arms are of girder type construction, and wherein said main feedwell is integrated into the girder structure of the drive arms, as well as connected directly to the underside of said auxiliary feedwell.

6. The combination according to claim 1, wherein said drive arms are located substantially above the liquid level, while the main feedwell is submerged.

7. The combination according to claim 1, wherein said main feedwell is connected to the underside of said drive arms, and wherein at least one of said ducts extends from said auxiliary feedwell downwardly externally of said channel structure.

8. The combination according to claim 1, wherein said annular auxiliary feedwell has an inner diameter substantially greater than the diameter of said main feedwell, and wherein said flow passage means comprise conduits connected to said main feedwell for introducing said streams tangentially into the respective annular paths.

9. The combination according to claim 1, wherein said main feedwell comprises an internal annular bottom shelf downwardly confining the lower annular stream.

10. The combination according to claim 9, with the addition of a second annular shelf spaced upwardly from said bottom shelf, and providing an annular partition between said upper and lower annular streams.

11. The combination according to claim 10, with the addition of a third annular shelf spaced upwardly from said second annular shelf, and together with said second annular shelf containing said upper annular stream.