

DESCRIPTION

Title of Invention

SOLID-LIQUID SEPARATOR

Technical Field

5 **[0001]** The present invention relates to a solid-liquid separator for separately taking out a solid component and a liquid component separated from the solids of sludge, in particular, the suspended solids (SS) contained in the liquid produced in, for example, a sewage plant, a night soil treatment plant, or a treatment plant for treating wastewater containing sludge in industries such as livestock and agricultural industries, food
10 manufacturing industry, and chemical industry.

Background Art

[0002] Currently, it is well known that wastewater containing sludge, that is, sewage suspension produced in, for example, a sewage plant, a night soil treatment plant, or a wastewater treatment plant in industries such as livestock and agricultural industries, food
15 manufacturing industry, and chemical industry, cannot be drained as it is from the viewpoint of environmental destruction. Thus, treating the sewage suspension with the suspended solids (SS) contained therein being removed as much as possible has been a challenge.

[0003] Patent Document 1 discloses a filtration apparatus having a plurality of layered
20 rotary filter units arranged at regular intervals in a discharge direction, each of the layered rotary filter units having a plurality of sets of filter pieces secured to a rotary shaft inserted therethrough, each of the sets having a large-diameter filter piece, a small-diameter filter piece and a spacer filter piece that are different in diameter and each having a thickness of about 1 mm to 2 mm. The rotary filter units are rotated in the
25 same direction. Outer circumferential edges of the large-diameter disk filter pieces of one of the mutually adjacent layered rotary filter units is disposed close to outer

circumferential edges of the small-diameter disk filter pieces of the other of the layered rotary filter units. In this filtration apparatus, each of the large-diameter disk filter pieces of the layered rotary filter unit is combined with adjacent ones, in front and rear, of the small-diameter disk filter pieces such that it faces the small-diameter disk filter pieces, so that when the layered rotary filter units are rotated, the large-diameter disk filter pieces rotate through narrow gaps between the small-diameter disk filter pieces, thereby filtering suspension liquid while preventing a clogging between filtering surfaces.

[0004] Patent Document 2 discloses a filtration apparatus for filtering suspension liquid, wherein large-diameter filter pieces and small-diameter filter pieces of the layered rotary filter units are different in diameter and have a thickness of about 0.2 mm to 1 mm.

[0005] Further, Patent Document 3 discloses a filtration apparatus for filtering suspension liquid, wherein large-diameter filter pieces and small-diameter filter pieces of the layered rotary filter units are different in diameter and have a smaller thickness of 0.05 mm to 0.8 mm. In a region where the outer circumferential edges of the large-diameter disk filter pieces of one of the mutually adjacent layered rotary filter units is disposed close to the outer circumferential edges of the small-diameter disk filter pieces of the other of the layered rotary filter units, that is, in a meshing region, each gap between the large-diameter disk filter pieces of the other forms a narrow clearance groove of 0.2 mm.

Prior Art Document

Patent Document

[0006] Patent Document 1: JP 2-31807 A

Patent Document 2: JP 2979296 B2

Patent Document 3: JP 53-141979 A

Summary of Invention

Problems that the Invention is to Solve

[0007] In the suspension filtration apparatus disclosed in Patent Document 1, the narrow gaps between the small-diameter disk filter pieces need to be at least slightly wider than the thickness of the large-diameter disk filter pieces that are rotated in a state in which they mesh with the small-diameter disk filter pieces. However, because the large-diameter disk filter pieces are completely fixed to the rotary shaft, they rotate along the same track. Therefore, there has been a drawback in that the cake, a product of dewatering filtration that is supposed to be scraped out, sticks and consolidates in the narrow gaps between the small diameter disk filter pieces in a region not covered by the thickness of the large-diameter disk filter pieces, thereby causing the clogging of the filtering surfaces and disabling the solid-liquid separation of the suspension.

[0008] Further, according to the suspension filtration apparatus disclosed in Patent Document 2, because the large-diameter and small-diameter disk filter pieces have very small thickness of about 0.2 mm to 1 mm, processing strain and heat strain are produced at the time of pressing and lasing, and such strain needs be removed. Further, when the diameter of the disk filter piece is increased, the influence of the strain becomes significant. That is, there has been a drawback in that both surfaces of the large-diameter disk filter pieces forming the narrow gap between the mutually adjacent small-diameter disk filter pieces contact and interfere, whereby, in addition to an increase in torque of the rotary shaft of the layered rotary filter unit, wear of the large-diameter and small-diameter disk filter pieces is facilitated.

[0009] Furthermore, according to the suspension filtration apparatus disclosed in Patent Document 3, the large-diameter and small-diameter disk filter pieces of the layered rotary filter unit have a smaller thickness of 0.05 mm to 0.8 mm, and in a region where the outer circumferential edges of the large-diameter disk filter pieces of one of the mutually adjacent layered rotary filter units is disposed close to the outer circumferential edges of the small-diameter disk filter pieces of the other of the layered rotary filter units, that is,

in a meshing region, each gap between the large-diameter disk filter pieces of the other forms a narrow clearance groove of 0.2 mm. Thus, the thickness of the large-diameter disk filter pieces inserted into the narrow clearance grooves is inevitably smaller than the narrow clearance grooves and is about 0.1 mm. Consequently, the clearance at the front and rear surfaces of each of the large-diameter disk filter pieces is $\{0.2 \text{ mm (narrow clearance groove)} - 0.1 \text{ mm (thickness of large-diameter disk filter piece)}\} / 2 = 0.05 \text{ mm}$, which requires precise assembling. Therefore, assembling is carried out while adjusting and confirming the clearance at the front and rear surfaces of each of the large-diameter disk filter pieces inserted into the respective narrow clearance grooves by inserting an adjusting member, such as an adjusting film having a thickness of about 0.05 mm, as means for adjusting the strain of the large-diameter and small-diameter disk filter pieces or an error in the thickness thereof. Thus, there has been a drawback that assembling requires time and skill.

[0010] In view of the problems described above, it is an object of the present invention to provide a solid-liquid separator which can stably maintain a filtration function, without clogging at filtering surfaces of a layered rotary filter unit, and without contact and interference at respective surfaces of large-diameter disk filter pieces so that rotary shaft torque of the layered rotary filter unit is not increased, and further without requiring time and skill in assembling.

Means for Solving the Problems

[0011] A solid-liquid separator according to the present invention is primarily characterized in that it comprises:

a treatment tank having an untreated liquid inlet, a solid outlet, and a filtrate outlet;

a plurality of triple layered rotary filter units provided between the untreated liquid inlet and the solid outlet, each of the triple layered rotary filter units including a

large-diameter disk filter piece, a small-diameter disk filter piece having a smaller diameter than the large-diameter disk filter piece, a plurality of projection-equipped disk filter pieces each having a smaller diameter than the large-diameter disk filter piece but larger than the small-diameter disk filter piece, and a rotary shaft; and

5 seal members provided on a feed side lateral wall and a discharge side lateral wall of the treatment tank to collect fine particles contained in the liquid being treated,

wherein an end face of the projection of each of the projection-equipped disk filter pieces abuts a back surface of an adjacent one of the projection-equipped disk filter pieces in series to form a plurality of filter grooves,

10 the large-diameter disk filter piece is disposed in a first filter groove of the plurality of filter grooves and is stacked on an outer periphery of the rotary shaft inserted therethrough, such that the large-diameter disk filter piece is movable in an axial direction,

the small-diameter disk filter piece is disposed in a second filter groove next to
15 the first filter groove and is stacked on the outer periphery of the rotary shaft inserted therethrough, such that the small-diameter disk filter piece is movable in the axial direction,

the triple layered rotary filter units are arranged at regular intervals in an ascending manner in a discharge direction towards the solid outlet and in two upper and
20 lower rows opposed to each other,

with regard to adjacent ones of the triple layered rotary filter units, an outer circumferential edge of the large-diameter disk filter piece of one of the triple layered rotary filter units is inserted into the second filter groove of the other of the triple layered rotary filter units so as to be close to the projection of the projection-equipped disk filter
25 piece and an outer circumferential edge of the small-diameter disk filter piece of the other triple layered rotary filter unit,

outer edges of the seal members are disposed to face closely, with a clearance, to the outer circumferential edge of the projection-equipped disk filter piece of the triple layered rotary filter unit at an end of each of the two upper and lower rows on the solid outlet side and to the outer circumferential edge of the projection-equipped disk filter piece of the triple layered rotary filter unit at the beginning of the lower row on the untreated liquid inlet side, among the triple layered rotary filter units arranged in the two upper and lower rows opposed to each other, and

the large-diameter disk filter piece and the small-diameter disk filter piece are configured to rotate synchronously with the rotary shaft while oscillating in the axial direction in the first filter groove and the second filter groove respectively.

[0012] It is preferable that the solid-liquid separator according to the present invention further comprise a double layered rotary filter unit including a pair of projection-equipped disk filter pieces, a small-diameter disk filter piece, and a rotary shaft,

wherein an end face of the projection of one of the pair of projection-equipped disk filter pieces of the double layered rotary filter units abuts a back surface of the other projection-equipped disk filter piece in series to form a plurality of third filter grooves,

the small-diameter disk filter piece of the double layered rotary filter unit is disposed in the third filter grooves and is stacked on an outer periphery of the rotary shaft of the double layered rotary filter unit inserted therethrough, so as to be movable in the axial direction,

the double layered rotary filter unit is arranged at the end of each of the two upper and lower rows of the triple layered rotary filter units opposed to each other and/or at the beginning of the lower row on the untreated liquid inlet side, and

the outer edges of the seal members are disposed to face closely, with a clearance, to an outer circumferential edge of the double layered rotary filter unit.

[0013] It is also preferable that the solid-liquid separator according to the present invention be configured such that:

filtrate holes are provided concentrically in the projection-equipped disk filter pieces and the large-diameter disk filter pieces of the plurality of triple layered rotary filter units and in the projection-equipped disk filter pieces of the double layered rotary filter unit arranged at the beginning of the lower row on the untreated liquid inlet side, and filtrate cutout holes are provided concentrically in the small-diameter disk filter pieces of the plurality of triple layered rotary filter units and in the disk filter pieces of the double layered rotary filter unit,

the filtrate holes and the filtrate cutout holes form filtrate passages inside the triple layered rotary filter units and the double layered rotary filter unit after being stacked,

openings at filtrate sending terminals of the respective filtrate passages lead into an inside of a filtrate chamber provided outside the lateral wall of the treatment tank, and

a lower wall of the filtrate chamber is provided with a filtrate chamber outlet.

[0014] Further, in the solid-liquid separator according to the present invention, the projection-equipped disk filter pieces are preferably made of resin.

Advantages of the Invention

[0015] According to the solid-liquid separator of the invention, unlike Patent Document 1 to 3, the large-diameter and small-diameter disk filter pieces are not stacked in a fixed manner in the triple layered rotary filter units, so that they can rotate while oscillating in the axial direction in the filter grooves. This provides oscillation actions of the small-diameter disk filter piece and the large-diameter disk filter piece in the area in the respective filter grooves wider than the thickness of the large-diameter and small-diameter disk filter pieces, that is, between the end faces of the projection-equipped disk filter pieces, an oscillation action of the large-diameter disk filter piece of the other

triple layered rotary filter unit inserted into the filter groove, and in addition, a shearing action produced by the respective rotations of the outer circumferential edge of the large-diameter disk filter piece of one of the triple layered rotary filter units and the outer circumferential edge of the small-diameter disk filter piece of the other of the triple layered rotary filter units facing this large-diameter disk filter piece, thereby preventing the cake, a product of dewatering filtration that is supposed to be scraped out, from sticking and consolidating in the narrow gaps of the filter grooves. This self-cleaning effect is advantageous in that it can always prevent the filtering surfaces from being clogged.

[0016] Further, in Patent Document 1 to 3, the filter grooves are formed by stacking the large-diameter and small-diameter disk filter pieces in a fixed manner. Therefore, the accuracy of the width and position of the filter grooves is greatly affected by the accuracy of the thickness and flatness of the filter pieces, the fastening strengths at the time of stacking and assembling, and the like. Thus, meticulous care and adjustment are required at the time of assembling, and the assembling requires great effort and skill. In contrast, in the triple layered rotary filter unit according to the invention, the large-diameter and small-diameter disk filter pieces are disposed in the respective filter grooves, which are formed by the abutment of the end faces of the projections of the projection-equipped disk filter pieces, such that they are movable in the axial direction. That is, they are mounted in a loosely fitted manner. With this structure, accuracy of the filter grooves required with respect to the strain and variations (errors) in the thickness of the respective filter pieces is ensured very easily, without paying meticulous care and adjustment at the time of assembling. This eliminates the need for the excessive precision of the thickness and flatness of the filter pieces, and also eliminates the need for the deftness in assembling. Especially, when assembling a layered rotary filter unit having a large width to enhance the treatment performance, there is a great advantage that

even an unskilled person can assemble it quickly and accurately.

Brief Description of the Drawings

[0017] Fig. 1 is a longitudinal sectional view of Embodiment 1 of the present invention;

Fig. 2 is a sectional view taken along the line X-X from the direction of the
5 arrow in Fig. 1;

Fig. 3 illustrates a triple layered rotary filter unit according to Embodiment 1 or
2 of the present invention, wherein (a) is a front view, and (b) is a longitudinal sectional
view thereof;

Fig. 4 is an enlarged side view of a relevant portion of the triple layered rotary
10 filter units according to Embodiment 1 or 2 of the present invention, illustrating how they
are disposed adjacent to each other;

Fig. 5 illustrates a large-diameter disk filter piece forming the triple layered
rotary filter unit according to Embodiment 1 or 2 of the present invention, wherein (a) is
a front view, and (b) is a longitudinal sectional view thereof;

15 Fig. 6 illustrates a small-diameter disk filter piece forming the triple or double
layered rotary filter unit according to Embodiment 1 or 2 of the present invention,
wherein (a) is a front view, and (b) is a longitudinal sectional view thereof;

Fig. 7 illustrates a projection-equipped disk filter piece forming the triple or
double layered rotary filter unit according to Embodiment 1 or 2 of the present invention,
20 wherein (a) is a front view, and (b) is a longitudinal sectional view thereof;

Fig. 8 is a longitudinal sectional view of Embodiment 3 based on Embodiment 1
of the present invention;

Fig. 9 is a sectional view taken along the line Y-Y from the direction of the arrow
in Fig. 8.

25 Fig. 10 illustrates a triple layered rotary filter unit according to Embodiment 3 of
the present invention, wherein (a) is a front view, and (b) is an A-A sectional view

thereof;

Fig. 11 is an enlarged side view of a relevant portion of the plurality of triple layered rotary filter units according to Embodiment 3 of the present invention, illustrating how they are disposed adjacent to each other;

5 Fig. 12 illustrates a large-diameter disk filter piece forming the triple layered rotary filter unit according to Embodiment 3 of the present invention, wherein (a) is a front view, and (b) is a longitudinal sectional view thereof;

Fig. 13 illustrates a small-diameter disk filter piece forming the triple layered rotary filter unit according to Embodiment 3 of the present invention, wherein (a) is a front view, and (b) is a longitudinal sectional view thereof;

Fig. 14 illustrates a projection-equipped disk filter piece forming the triple layered rotary filter unit according to Embodiment 3 of the present invention, wherein (a) is a front view, and (b) is a longitudinal sectional view thereof;

Fig. 15 is a longitudinal sectional view of an example of Embodiment 2 based on Embodiment 1 of the present invention, in which the ends of the two upper and lower rows on the solid outlet side are configured as double layered rotary filter units;

Fig. 16 is a longitudinal sectional view of another example of Embodiment 2 based on Embodiment 1 of the present invention, in which the beginning of the lower row on the untreated liquid inlet side is configured as a double layered rotary filter unit; and

20 Fig. 17 is a longitudinal sectional view of still another example of Embodiment 2 based on Embodiment 1 of the present invention, in which the ends of the two upper and lower rows on the solid outlet side and the beginning of the lower row on the untreated liquid inlet side are configured as double layered rotary filter units.

Best Mode for Carrying Out the Invention

25 **[0018]** Hereinafter, a solid-liquid separator according to embodiments of the present invention will be described in detail with reference to the drawings and based on the

following Embodiments 1 to 4. However, the present invention is not limited by these embodiments. A solid-liquid separator according to embodiments of the present invention includes a treatment tank having an untreated liquid inlet, a solid outlet, and a filtrate outlet, a plurality of triple layered rotary filter units provided between the
5 untreated liquid inlet and the solid outlet, each of the triple layered rotary filter units including a large-diameter disk filter piece, a small-diameter disk filter piece having a smaller diameter than the large-diameter disk filter piece, a plurality of projection-equipped disk filter pieces each having a smaller diameter than the large-diameter disk filter piece but larger than the small-diameter disk filter piece, and a
10 rotary shaft, and seal members provided on a feed side lateral wall and a discharge side lateral wall of the treatment tank to collect fine particles contained in the liquid being treated. An end face of the projection of each of the projection-equipped disk filter pieces abuts a back surface of an adjacent one of the projection-equipped disk filter pieces in series to form a plurality of filter grooves. The large-diameter disk filter piece
15 is disposed in a first filter groove of the plurality of filter grooves and is stacked on an outer periphery of the rotary shaft inserted therethrough, such that the large-diameter disk filter piece is movable in an axial direction. The small-diameter disk filter piece is disposed in a second filter groove next to the first filter groove and is stacked on the outer periphery of the rotary shaft inserted therethrough, such that the small-diameter disk filter
20 piece is movable in the axial direction. The triple layered rotary filter units are arranged at regular intervals in an ascending manner in a discharge direction towards the solid outlet and in two upper and lower rows opposed to each other. With regard to adjacent ones of the triple layered rotary filter units, an outer circumferential edge of the large-diameter disk filter piece of one of the triple layered rotary filter units is inserted
25 into the second filter groove of the other of the triple layered rotary filter units so as to be close to the projection of the projection-equipped disk filter piece and an outer

circumferential edge of the small-diameter disk filter piece of the other triple layered rotary filter unit. Outer edges of the seal members are disposed to face closely, with a clearance, to the outer circumferential edge of the projection-equipped disk filter piece of the triple layered rotary filter unit at an end of each of the two upper and lower rows on the solid outlet side and to the outer circumferential edge of the projection-equipped disk filter piece of the triple layered rotary filter unit at the beginning of the lower row on the untreated liquid inlet side, among the triple layered rotary filter units arranged in the two upper and lower rows opposed to each other. The large-diameter disk filter piece and the small-diameter disk filter piece are configured to rotate synchronously with the rotary shaft while oscillating in the axial direction in the first filter groove and the second filter groove respectively.

Embodiment 1

[0019] With reference to Figs. 1 to 7, an upper portion of a treatment tank 9 is provided with an untreated liquid inlet 10 from which untreated liquid is fed, and a lower portion of the treatment tank 9 is provided with a filtrate outlet 12 from which the filtrate after the solid-liquid separation is discharged outside the treatment tank 9. A lateral side portion of the treatment tank 9 is provided with a solid outlet 11 from which a cake, a solid product of dewatering filtration after the solid-liquid separation, is discharged outside the treatment tank 9. Inside the treatment tank 9, and between the untreated liquid inlet 10 and the solid outlet 11, as shown in Fig. 1, triple layered rotary filter units 1t are arranged at regular intervals in ascending manner in a discharge direction towards the solid outlet 11 and in two upper and lower rows opposed to each other.

[0020] As shown in Figs. 3 and 5 to 7, each of the triple layered rotary filter units 1t includes a large-diameter disk filter piece 2, a small-diameter disk filter piece 3 having a smaller diameter than the large-diameter disk filter piece 2, a rotary shaft 4, and a plurality of projection-equipped disk filter pieces 5 each having a smaller diameter than

the large-diameter disk filter piece 2 but larger than the small-diameter disk filter piece 3. The rotary shaft 4 has an engaging function provided by a D cut, which is obtained by cutting a portion of a cylinder to be a flat surface, or by a key (not shown). As shown in Fig. 2, the rotary shaft 4 is pivotally supported by bearings 17 disposed on outer sides of the front side lateral wall 9f and the rear lateral wall 9r of the treatment tank 9, and is rotated by a drive transmission member 16 (e.g., a worm gear) provided on the outer side of the front lateral wall 9f. At the center of each of the filter pieces 2, 3, 5, having different diameters respectively, a shaft hole that fits the engaging configuration of the rotary shaft 4 is provided so as to rotate synchronously with the rotary shaft 4. The plurality of projection-equipped disk filter pieces 5 is provided with projections 5t, and forms filter grooves S (first and second filter grooves) by arranging the end faces of the projections 5t to abut the back surface of the adjacent one of the projection-equipped disk filter pieces 5 in series. In the respective filter grooves S, the large-diameter disk filter piece 2 and the small-diameter disk filter piece 3 are disposed alternately such that they are movable in the axial direction. In this manner, the large-diameter disk filter piece 2 and the small-diameter disk filter piece 3 are configured such that they can rotate synchronously with the rotary shaft 4 while oscillating in the axial direction in the respective filter grooves S.

[0021] With regard to the triple layered rotary filter unit 1t having this configuration, a method of engaging the respective filter pieces 2, 3, 5 with the rotary shaft 4 will be described below. (i) Firstly, among the plurality of projection-equipped disk filter pieces 5, the first projection-equipped disk filter piece 5 is attached to the outer periphery of the rotary shaft 4 by being inserted from the back surface opposite to the side where the projections 5t are provided, (ii) next, the large-diameter disk filter piece 2 is attached to the rotary shaft 4 by being inserted such that the projection loose engaging holes 2h of the large-diameter disk filter piece 2 engage with the projections 5t of the first

projection-equipped disk filter piece 5, (iii) next, the second projection-equipped disk filter piece 5, different from the first projection-equipped disk filter piece 5, is attached by being inserted from the back surface opposite to the side where the projections 5t are provided, and the back surface of the second projection-equipped disk filter piece 5 is
 5 butted against the end faces of the projections 5t of the first projection-equipped disk filter piece 5 to form the filter groove S, (iv) next, the small-diameter disk filter piece 3 is attached to the rotary shaft 4 by being inserting such that the projections 5t of the second projection-equipped disk filter piece 5 engage with the projection cutout holes of the small-diameter disk filter piece 3, and (v) next, a back surface of a new first
 10 projection-equipped disk filter piece 5 is butted against the end faces of the projections 5t of the second projection-equipped disk filter piece 5 to form another filter groove S.

[0022] The plurality of triple layered rotary filter units 1t formed by repeating the steps (i) to (v) described above are configured such that, as shown in Fig. 4, with regard to adjacent ones of the triple layered rotary filter units 1t, the outer circumferential edge of
 15 the large-diameter disk filter piece 2 of one of the triple layered rotary filter units 1t enters the second filter groove S of the other of the triple layered rotary filter units 1t, and is disposed close to the projection 5t portion of the projection-equipped disk filter piece 5 and the outer circumferential edge of the small-diameter disk filter piece 3 of the other triple layered rotary filter unit 1t.

[0023] As shown in Fig. 1, to efficiently collect fine particles contained in the liquid being treated, seal members 15 are provided on the feed side lateral wall 9s and on the discharge side lateral wall 9d of the treatment tank 9. The relevant outer edges of the seal members 15 are disposed to face closely, with a slight clearance, to the outer circumferential edges of the projection-equipped disk filter pieces 5 of the triple layered
 20 rotary filter units 1t provided at an end of each of the two upper and low rows on the solid outlet 11 side and at the beginning of the lower row on the untreated liquid inlet 10

side. Further, it is advantageous to provide brushes having small sliding resistance at the outer circumferential edges of the seal members 15. This can further enhance the sealing function and also can suppress an increase in the torque of the rotary shaft 4.

Embodiment 2

5 [0024] Embodiment 2 will be described using Figs. 15 to 17 as examples. In addition to the triple layered rotary filter units 1t arranged in two upper and lower rows at regular intervals in ascending manner in the discharge direction towards the solid outlet 11 and in two upper and lower rows opposed to each other, the treatment tank 9 is provided with a double layered rotary filter unit 1w having a pair of projection-equipped disk filter pieces
10 5, 5, a small-diameter disk filter piece 3, and a rotary shaft 4. The double layered rotary filter unit 1w is provided at the end of each of the upper and lower rows on the solid outlet 11 side and/or at the beginning of the lower row on the untreated liquid inlet 10 side.

[0025] A method of assembling the double layered rotary filter unit 1w will be
15 described below. (vi) Firstly, one of the paired projection-equipped disk filter pieces 5, 5 is attached to the outer periphery of the rotary shaft 4 by being inserted from the back surface opposite to the side where the projections 5t are provided, (vii) next, the small-diameter disk filter piece 3 is attached to the rotary shaft 4 by being inserted such that the projections 5t of the projection-equipped disk filter piece 5 engage with the
20 projection cutout holes 3h of the small-diameter disk filter piece 3 and such that the small-diameter disk filter piece 3 is movable in the axial direction, and (viii) next, the back surface of the other projection-equipped disk filter piece 5 is butted against the end face of the projections of the previously described projection-equipped disk filter piece 5 to form a filter groove S (a third filter groove).

25 [0026] The outer edges of the seal members 15 provided on the side walls of the treatment tank 9 are disposed to face closely to, with a slight clearance, the outer

circumferential edges of the double layered rotary filter units 1w formed by repeating the steps (vi) to (viii) described above. It is advantageous to form the leading end of the outer edges of the seal members 15 as a spatula-like edge having small sliding resistance like a scraper.

5 **Embodiment 3**

[0027] Embodiment 3 will be described using Figs. 8 to 14 as examples. With regard to the triple layered rotary filter units 1t arranged at regular intervals in an ascending manner in the discharge direction towards the solid outlet 11 and in two upper and lower rows opposed to each other, and with regard to the double layered rotary filter unit 1w arranged at the beginning of the lower row on the untreated liquid inlet 10 side, as shown in Figs. 12 to 14, filtrate holes 7 are concentrically provided in the projection-equipped disk filter piece 5 and in the large-diameter disk filter piece 2, and filtrate cutout holes 8 are concentrically provided in the small-diameter disk filter piece 3. As shown in Figs. 9 to 11, the filtrate holes 7 and the filtrate cutout holes 8 form filtrate passages 6 inside the respective layered rotary filter units 1t, 1w after being stacked. The opening at the filtrate sending terminal of the passage 6 leads to an inside of a filtrate chamber 13 provided outside the rear lateral wall 9r of the treatment tank 9, and a filtrate chamber outlet 14 is formed at the lower wall of the filtrate chamber 13.

Embodiment 4

20 [0028] In this embodiment, the projection-equipped disk filter pieces 5 forming the triple layered rotary filter unit 1t and the double layered rotary filter unit 1w are configured as resin molded pieces, which are free from rust, light in weight, not requiring processing, and suitable for mass production.

[0029] According to the solid-liquid separator of the embodiments, the large-diameter disk filter piece 2 and small-diameter disk filter piece 3 are not stacked in a fixed manner in the triple layered rotary filter unit 1t, so that the large-diameter disk filter piece 2 and

small-diameter disk filter piece 3 can rotate while oscillating in the axial direction in the respective filter grooves S. This provides the oscillation actions of the large-diameter disk filter piece 2 and small-diameter disk filter piece 3 in the area in the respective filter grooves S wider than the thickness of the large-diameter disk filter piece 2 and small-diameter disk filter piece 3, that is, between the end faces of the projection-equipped disk filter pieces 5, the oscillation action of the large-diameter disk filter piece 2 of the other triple layered rotary filter unit 1t inserted into the filter groove S, and in addition, a shearing action produced by the respective rotations of the outer circumferential edge of the large-diameter disk filter piece 2 and the outer circumferential edge of small-diameter disk filter piece 3 of the other triple layered rotary filter unit 1t disposed to face this large-diameter disk filter piece 2, thereby preventing the product of dewatering filtration (the cake) that is supposed to be scraped out, from sticking and consolidating in the narrow gaps of the filter grooves S. Due to this so-called self-cleaning effect that prevents the cake from sticking and consolidating, the filtering surfaces can always be prevented from being clogged.

[0030] Conventionally, the filter grooves are formed by stacking the large-diameter and small-diameter disk filter pieces in a fixed manner. Therefore, the accuracy of the width and position of the filter grooves is greatly affected by the accuracy of the thickness and flatness of the filter pieces, the fastening strengths at the time of stacking and assembling, and the like. Thus, meticulous care and adjustment are required at the time of assembling, and the assembling requires great effort and skill. In contrast, in the triple layered rotary filter unit 1t according to the present embodiments, the large-diameter disk filter piece 2 and the small-diameter disk filter piece 3 are disposed in the respective filter grooves S, which is formed by the abutment of the end faces of the projections of the projection-equipped disk filter pieces 5, such that they are movable in the axial direction, that is, they are mounted in a loose fit manner. With this structure, accuracy of the filter

grooves S required with respect to the strain and variations (errors) in the thickness of each of the large-diameter disk filter piece 2 and the small-diameter disk filter piece 3 is ensured very easily, without paying meticulous care and adjustment at the time of assembling. This eliminates the need for the excessive precision of the thickness and flatness of the large-diameter disk filter piece 2 and the small-diameter disk filter piece 3, and also eliminates the need for the deftness in assembling. Especially, when assembling a layered rotary filter unit having a large width to enhance the treatment performance, there is an advantage that even an unskilled person can assemble it quickly and accurately

[0031] Further, according to the solid-liquid separator of the embodiments, because the seal members 15 provided on the lateral walls of the treatment tank 9 can be configured such that they are disposed to face closely to, with a slight clearance, the outer circumferential edges of the triple layered rotary filter units 1t or the double layered rotary filter units 1w, it is not necessary to consider the outer edges of the seal members 15 interfering with the large-diameter disk filter pieces 2. This configuration is excellent in the assembling efficiency, and allows the closely opposed outer edges of the seal members 15 to be formed long in the axial direction. Therefore, fine particles contained in the liquid being treated can be collected efficiently without leakage.

[0032] Further, according to the solid-liquid separator of the embodiments, with the layered rotary filter units 1t, 1w formed with the filtrate passages 6, as compared with a layered rotary filter unit having no filtrate passage, additional water discharge from the filtrate chamber outlet 14 of the lower wall of the filtrate chamber 13 through the filtrate passages 6 is provided, so that the filtrate separation performance of the large-diameter and small-diameter disk filter piece 2, 3 oscillating and rotating in the respective filter groove S is improved. Consequently, a cake having a low water content percentage can be collected.

[0033] According to the solid-liquid separator of the embodiments, because the projection-equipped disk filter piece 5, which is the heaviest piece in the layered rotary filter units 1t, 1w, is made of resin, the weight of the layered rotary filter units 1t, 1w can be greatly reduced. This can reduce the drive power, can maintain the formation of the clog-free and clean filter grooves S due to being rustless, and also can produce the layered rotary filter units 1t, 1w as resin molded product. Thus, the projection-equipped disk filter pieces 5 of high dimension accuracy can be mass produced without processing, are inexpensive and are easy to assemble. Especially, because the layered rotary filter units 1t, 1w can be assembled easily with high accuracy, a stable filtration function can be provided.

[0034] While the present invention has been described above in detail and with reference to certain embodiments thereof, it is apparent to those skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope of the invention. Further, the number, the location, the shape and the like of the components described above are not limited to the above embodiments, and may be changed to the number, location, shape and the like that are suitable in implementing the present invention.

[0035] This application is based on the Japanese Patent Application No. 2012-205180 filed on September 19, 2012, the content of which is incorporated herein by reference.

CLAIMS

1. A solid-liquid separator comprising:

a treatment tank having an untreated liquid inlet, a solid outlet, and a filtrate
5 outlet;

a plurality of triple layered rotary filter units provided between the untreated
liquid inlet and the solid outlet, each of the triple layered rotary filter units including a
large-diameter disk filter piece, a small-diameter disk filter piece having a smaller
diameter than the large-diameter disk filter piece, a plurality of projection-equipped disk
10 filter pieces each having a smaller diameter than the large-diameter disk filter piece but
larger than the small-diameter disk filter piece, and a rotary shaft; and

seal members provided on a feed side lateral wall and a discharge side lateral
wall of the treatment tank to collect fine particles contained in liquid being treated,

wherein an end face of the projection of each of the projection-equipped disk
15 filter pieces abuts a back surface of an adjacent one of the projection-equipped disk filter
pieces in series to form a plurality of filter grooves,

the large-diameter disk filter piece is disposed in a first filter groove of the
plurality of filter grooves and is stacked on an outer periphery of the rotary shaft inserted
therethrough, such that the large-diameter disk filter piece is movable in an axial
20 direction,

the small-diameter disk filter piece is disposed in a second filter groove next to
the first filter groove and is stacked on the outer periphery of the rotary shaft inserted
therethrough, such that the small-diameter disk filter piece is movable in the axial
direction,

25 the triple layered rotary filter units are arranged at regular intervals in an
ascending manner in a discharge direction towards the solid outlet and in two upper and

lower rows opposed to each other,

with regard to adjacent ones of the triple layered rotary filter units, an outer circumferential edge of the large-diameter disk filter piece of one of the triple layered rotary filter units is inserted into the second filter groove of the other of the triple layered rotary filter units so as to be close to the projection of the projection-equipped disk filter piece and an outer circumferential edge of the small-diameter disk filter piece of the other triple layered rotary filter unit,

outer edges of the seal members are disposed to face closely, with a clearance, to the outer circumferential edge of the projection-equipped disk filter piece of the triple layered rotary filter unit at an end of each of the two upper and lower rows on the solid outlet side and to the outer circumferential edge of the projection-equipped disk filter piece of the triple layered rotary filter unit at the beginning of the lower row on the untreated liquid inlet side, among the triple layered rotary filter units arranged in the two upper and lower rows opposed to each other, and

the large-diameter disk filter piece and the small-diameter disk filter piece are configured to rotate synchronously with the rotary shaft while oscillating in the axial direction in the first filter groove and the second filter groove respectively.

2. The solid-liquid separator according to claim 1, further comprising a double layered rotary filter unit including a pair of projection-equipped disk filter pieces, a small-diameter disk filter piece, and a rotary shaft, wherein

an end face of the projection of one of the pair of projection-equipped disk filter pieces of the double layered rotary filter units abuts a back surface of the other projection-equipped disk filter piece in series to form a plurality of third filter grooves,

the small-diameter disk filter piece of the double layered rotary filter unit is disposed in the third filter grooves and is stacked on an outer periphery of the rotary shaft

of the double layered rotary filter unit inserted therethrough, so as to be movable in the axial direction,

the double layered rotary filter unit is arranged at the end of each of the two upper and lower rows of the triple layered rotary filter units opposed to each other and/or at the beginning of the lower row on the untreated liquid inlet side, and

the outer edges of the seal members are disposed to face closely, with a clearance, to an outer circumferential edge of the double layered rotary filter unit.

3. The solid-liquid separator according to claim 1 or 2, wherein

filtrate holes are provided concentrically in the projection-equipped disk filter pieces and the large-diameter disk filter pieces of the plurality of triple layered rotary filter units and in the projection-equipped disk filter pieces of the double layered rotary filter unit arranged at the beginning of the lower row on the untreated liquid inlet side, and filtrate cutout holes are provided concentrically in the small-diameter disk filter pieces of the plurality of triple layered rotary filter units and in the disk filter pieces of the double layered rotary filter unit,

the filtrate holes and the filtrate cutout holes form filtrate passages inside the triple layered rotary filter units and the double layered rotary filter unit after being stacked,

openings at filtrate sending terminals of the respective filtrate passages lead into an inside of a filtrate chamber provided outside the lateral wall of the treatment tank, and a lower wall of the filtrate chamber is provided with a filtrate chamber outlet.

4. The solid-liquid separator according to any one of claims 1 to 3, wherein the projection-equipped disk filter pieces are made of resin.