

Description

MEMBRANE FILTRATING APPARATUS AND OPERATION METHOD THEREOF

Technical Field

[0001]

The present invention relates to a structure of an apparatus for separating and filtrating water by a hollow fiber membrane, and more particularly, to a membrane filtrating apparatus capable of stably performing membrane filtration at a high return rate even when raw water has a high turbidity.

Background Art

[0002]

Since a membrane filtrating method of filtrating water by a separation membrane has characteristics such as energy saving, space saving, power saving, and improvement of water quality, the method has been widely used in various fields. For example, a membrane filtration using a microfiltration membrane or an ultrafiltration membrane has been applied to a water-purifying producing process for producing industrial water or tap water from river water, groundwater, and sewage processing water.

[0003]

A hollow fiber membrane module has been applied to

various fluid processing fields such as chemical refinement, sterile filtration, and clarifying, from the point of securing a large membrane area per unit volume.

[0004]

As the hollow fiber membrane module, there are a pressurized hollow fiber membrane module and a submerged hollow fiber membrane module. In the pressurized hollow fiber membrane, a pressure-resistance cylindrical case having no opening is loaded with a bundle of a plurality of hollow fiber membranes, both end portions of the membrane bundle and an inner wall of the cylindrical case are adhered and fixed, one end or both ends is cut to open the inner portion of the hollow fiber membranes, the opening end is provided with a filtrated water collecting portion to collect filtrated water, a raw liquid supply port for supplying raw liquid into the cylindrical case is provided, and pressed raw water introduced into the module is filtrated by a hollow fiber membrane surface.

Meanwhile, in the submerged hollow fiber membrane, both ends of hollow fiber membrane bundle are adhered and fixed by adhesives, one end or both ends is cut to open the inner portion of the hollow fiber membranes, the opening portion is provided with a filtrated water collecting portion to collect filtrated water, the membrane module is immersed into raw water in a submersion tank opened to the

air, and the permeated water side provided with the filtrated water collecting portion is absorbed and filtrated.

[0005]

The pressurized hollow fiber membrane module is capable of increasing a treatment amount per membrane area from the point of setting filtration pressure lager than that of the submerged type. As a result, it is possible to reduce the number of membranes for the filtration process and thus to reduce the installation space. Meanwhile, the submerged hollow fiber membrane module is used by immersing the hollow fiber membrane bundle in the infiltration raw water without the pressure-resistance cylindrical case around the hollow fiber membranes. Accordingly, it is easy to discharge suspended substances clogged between the hollow fiber membranes, that is, there are advantages in that a suspended material discharge performance is good, and that thus it is possible to perform membrane filtration even in high-turbidity water. Also, there is an advantage in reducing the cost of equipments, since the filtration system is simple and the number of auxiliary pipes is small.

[0006]

As described above, the submerged membrane module has an advantage in having a good performance in

discharging suspended substances clogged between the membranes since no pressure-resistance cylindrical case is provided, and an advantage in enabling membrane filtration to be performed even in high-turbidity water. Therefore, various studies with respect to a submersion tank filled with raw water in which the submerged membrane module is disposed have been made so that membrane filtration can be performed even in higher-turbidity raw water.

[0007]

For example, in Patent Document 1, there is disclosed an apparatus in which a plurality of membrane modules including a plurality of tube-shaped ceramic separation membranes disposed parallel are piled, an air diffusion pipe is disposed thereunder, and a precipitation zone is formed in an area thereunder. In this apparatus, the membrane modules are disposed horizontally so that a longitudinal direction of the pipe-shaped separation membranes corresponds to a horizontal direction. The apparatus is provided with a precipitation zone to reduce a turbidity of raw water around the membrane modules so that suspended components are easily precipitated in the precipitation zone when the suspended components are peeled off from a surface of the separation membranes by air scrubbing to be circulated in the tank.

[0008]

In Patent Document 2, it is disclosed that an obstacle plate is disposed between an air diffusion device and a bottom of a submersion tank to prevent suspended components precipitated in a precipitation zone from floating up again by air scrubbing.

[0009]

In Patent Document 3, there is disclosed an apparatus in which a flat membrane module is disposed in an aeration tank (treatment tank) for an active sludge treatment, and an air diffusion device is disposed thereunder, wherein an area of the treatment tank occupied in the same horizontal section is set three times or more as large as an area of a membrane module. The inner area of the treatment tank is expanded as described above for easy in-tank circulation flow caused by air supplied from the air diffusion device, thereby improving a performance of discharging suspended substances clogged between the membranes.

[0010]

However, particularly, in the submerged hollow fiber membrane module among the submerged membrane modules, since the plurality of hollow fiber membranes are bundled and disposed in the module so that the membrane area per unit volume is large. Accordingly, there is a demerit that suspended components are easily filled between the

membranes. Accordingly, it is difficult to cope with high-turbidity raw water only by the conventional technique described above. For this reason, there has been generally employed a constant air scrubbing method of performing an air scrubbing in a filtration process as well as in a physical cleaning process, a method (full drain method) of regularly draining most of raw water concentrated in a submersion tank to flow relatively clear raw water before concentration, or a method of combining the both methods.

[0011]

Although the constant air scrubbing method is widely used mainly in sewage waste water treatment, there are a practical problem in enormous running cost, and a problem in lacking reliability as a stable operation method for high-turbidity raw water.

[0012]

On the other hand, in the full drain method, the full amounts of water are discharged at the time when a concentration of concentrated water in a tank rises and reaches a predetermined concentration, and then the tank is filled with raw water before concentration again. Accordingly, this method is reliable as a stable operation method for high-turbidity raw water. However, the submerged membrane module is disposed in a wide submersion

tank. Therefore, in case of employing the full drain method in the conventional apparatus having a good performance in discharging suspended substances, most of concentrated water in the submersion tank is discharged, and thus there is a problem that an operation return rate thereof largely decreases.

[0013]

Herein, the inner surface of the submersion tank may be set in the similar shape with the membrane module and the substantially same size as the membrane module. In this case, it is possible to solve the problem that the operation return rate largely decreases, even in case of employing the full drain method. However, in the case where the inner surface of the submersion tank has the similar shape with the membrane module and the substantially same size as the membrane module, there is little functional difference from the pressurized module formed by inserting a hollow fiber membrane bundle into a pressure-resistance cylindrical case, so that the performance in discharging suspended substances clogged between the membranes will be largely decreased.

[0014]

As for the membrane filtrating apparatus including the submerged hollow fiber membrane module described above, the improvement of the performance of discharging

suspended substances and the improvement of the operation return rate are in the relation of trade-off, and it is considered that it is difficult to satisfy both of them.

Patent Document 1: JP-A-2002-191946

Patent Document 2: JP-A-9-220441

Patent Document 3: JP-A-8-267083

Disclosure of the Invention

Problem that the Invention is to solve

[0015]

The invention is to provide a membrane filtrating apparatus in which a submerged hollow fiber membrane module for separating solid and liquid by absorption and filtration is disposed in a submersion tank, an air diffusion pipe is disposed below the hollow fiber membrane module, and a raw water supply port is disposed above the hollow fiber membrane module. According to the membrane filtrating apparatus, the performance in discharging suspended substances clogged between the membranes is high, an operation return rate thereof is kept high even in case of employing a full drain method, and it is possible to perform a stable membrane filtration operation at a high return rate even with respect to high-turbidity raw water.

Means for solving the Problem

[0016]

To solve the aforementioned problems, there is provided a membrane filtrating apparatus, in which a submerged hollow fiber membrane module formed by bundling a plurality of hollow fiber membranes is disposed in a submersion tank having a raw water supply port at an upper portion thereof and a drain port at a lower portion thereof so that a longitudinal direction of the hollow fiber membranes corresponds to a vertical direction, and an air diffusion pipe is disposed below the hollow fiber membrane module, wherein the raw water supply port is disposed upper than the hollow fiber membrane module, a ratio of a sectional area of the hollow fiber membrane to an in-tank sectional area of the submersion tank is 60% to 90% in a horizontal section with the hollow fiber membrane module disposed, a distance between the air diffusion pipe and the bottom of the submersion tank is 200 mm or more, and the drain port is disposed lower than the air diffusion pipe by 200 mm or more.

[0017]

In this case, it is preferable that a ratio of a sectional area of the hollow fiber membrane to an in-tank sectional area of the submersion tank is 70% to 80% in a horizontal section with the hollow fiber membrane module disposed, and a distance between the air diffusion pipe

and the bottom of the submersion tank is 200 mm to 700 mm.

[0018]

In addition, it is preferable that the hollow fiber membrane module has a structure in which a plurality of hollow fiber membranes are bundled at least at an upper end and a lower end thereof, the upper end side of the hollow fiber membrane bundle is bundled and fixed in a state where an end surface of the hollow fiber membranes is opened, a water collecting portion is disposed on the opened end surface of the hollow fiber membranes, and the lower end side of the hollow fiber membrane bundle is bundled by a plurality of small bundles in a state where an end surface of the hollow fiber membranes is closed.

[0019]

In addition, it is preferable that the drain port is disposed at the bottom of the submersion tank.

[0020]

In an operation method of filtrating raw water using the membrane filtrating apparatus, it is effective that a level of water in the submersion tank is regularly lowered to a position lower than the air diffusion pipe by 200 mm or more. In addition, in an operation method of filtrating raw water using the membrane filtrating apparatus, it is preferable that some of water in the submersion tank is regularly discharged from the drain

port.

Advantage of the Invention

[0021]

According to the invention, it is possible to keep a good performance in discharging suspended substances clogged between the membranes high, which is an advantage of the submerged hollow fiber membrane module, and it is possible to keep an operation return rate high, even when the whole or most of water in the submersion tank is regularly discharged. In addition, a considerable amount of suspended substances included in the raw water are not filtrated by the membranes and are precipitated in the vicinity of the bottom of the submersion tank, and thus exist in an accumulated or concentrated state. Therefore, it is possible to perform a stable membrane filtration operation at a high return rate even with respect to relative high-turbidity raw water.

Brief Description of the Drawings

[0022]

[Fig. 1] Fig. 1 is a schematic sectional view illustrating an embodiment of a membrane filtrating apparatus according to the invention.

[Fig. 2] Fig. 2 is a schematic sectional view

illustrating a horizontal sectional surface taken along a horizontal line Z-Z shown in Fig. 1, as viewed from the upper portion.

[Fig. 3] Fig. 3 is a schematic sectional view illustrating an embodiment of a hollow fiber membrane module used in the invention.

[Fig. 4] Fig. 4 is a schematic sectional view illustrating another embodiment of a membrane filtrating apparatus according to the invention.

[Fig. 5] Fig. 5 is a schematic sectional view illustrating a horizontal sectional surface taken along a horizontal line Z-Z shown in Fig. 4, as viewed from the upper portion.

[Fig. 6] Fig. 6 is a schematic sectional view illustrating flow of water in a submersion tank at the time of air scrubbing, in the membrane filtrating apparatus shown in Fig. 1.

Description of Reference Numerals and Signs

[0023]

1: Submersion tank, 1A: Inner surface of submersion tank, 2: Hollow fiber membrane module, 2B: Outer surface of hollow fiber membrane module, 3: Air diffusion pipe, 4: Air diffusion hole, 5: Permeated water pipe, 6: Raw water supply port, 7: Drain line, 8: Hollow fiber membrane, 9a,

9b: Adhered and fixed portion, 10: Water collecting cap,
11: Air introducing cylinder, 12: Penetration hole, 13:
Drain port

Best Mode for Carrying Out the Invention

[0024]

In a membrane filtrating apparatus according to the invention, a submerged hollow fiber membrane module formed by bundling a plurality of hollow fiber membranes is disposed in a submersion tank having a raw water supply port at an upper portion thereof and a drain port at a lower portion thereof so that a longitudinal direction of the hollow fiber membranes corresponds to a vertical direction, and an air diffusion pipe is disposed below the hollow fiber membrane module. The raw water supply port is disposed upper than the hollow fiber membrane module, a ratio of a sectional area of the hollow fiber membrane to an in-tank sectional area of the submersion tank is 60% to 90% in a horizontal section with the hollow fiber membrane module disposed, a distance between the air diffusion pipe and the bottom of the submersion tank is 200 mm or more, and the drain port is disposed lower than the air diffusion pipe by 200 mm or more.

[0025]

The invention will be described with reference to

the drawings schematically illustrating a membrane filtrating apparatus according to the best embodiment of the invention. The scope of the invention is not limited the embodiment.

[0026]

Fig. 1 is a schematic view illustrating an embodiment of a membrane filtrating apparatus according to the invention, and Fig. 2 is a schematic sectional view illustrating a submersion tank and a hollow fiber membrane module shown in Fig. 1 taken along a horizontal line Z-Z, as viewed from the upper portion thereof. Fig. 3 is an enlarged schematic sectional view illustrating an embodiment of the hollow fiber membrane module shown in Fig. 1. Fig. 4 is a schematic sectional view illustrating another embodiment of a membrane filtrating apparatus according to the invention. Fig. 5 is a schematic sectional view illustrating a submersion tank and a hollow fiber membrane module shown in Fig. 4 taken along a horizontal line Z-Z, as viewed from the upper portion thereof.

[0027]

In the invention, a submerged hollow fiber membrane module 2 has a structure formed by adhering and fixing both ends of a hollow fiber membrane bundle formed by collecting and bundling a plurality of (e.g., several

hundreds of to several tens of thousands of) hollow fiber membranes 8. Preferably, the hollow fiber membrane module is a type in which a filtrated water collecting portion is disposed on one end side 9a of the adhered and fixed portions in a state where an end surface of the hollow fiber membranes is opened, and the other end side 9b is adhered and fixed in a state where an end surface of the hollow fiber membranes is closed (as exemplified in Fig. 1 and Fig. 3, etc.). However, the hollow fiber membrane module may a type in which both ends of the adhered and fixed portions is adhered and fixed in a state where both end surfaces of the hollow fiber membranes are opened, and filtrated water collecting portions are provided thereon.

[0028]

The hollow fiber membranes 8 are not limited particularly if they are porous hollow fiber membranes having desired filtration performance, but preferably, made of one kind selected from the group consisting of polymer materials such as polyacrylonitrile, polyphenylene sulfone, polyphenylene sulfide sulfone, polyvinylidene fluoride, polypropylene, polyethylene, polysulfone, polyvinyl alcohol, and acetic acid cellulos, or consisting of inorganic materials such as ceramics, and more preferably, made of polyvinylidene fluoride in terms of membrane strength. A pore diameter formed on the

surface of the hollow fiber membranes is not limited particularly, but may be selected to have desired filtration performance in the range of 0.001 μm to 1 μm . An outer diameter of the hollow fiber membranes 8 is also not limited particularly, but preferably, in the range of 250 μm to 2000 μm , because fluctuation of the hollow fiber membranes is large and a cleaning property is excellent.

[0029]

The adhesive used to adhere and fix both ends of the hollow fiber membrane bundle is not limited particularly, but it is preferable to use thermosetting resin such as epoxy resin and urethane resin.

[0030]

The adhered and fixed portions 9a and 9b formed at both ends of the hollow fiber membrane bundle are connected to each other through a plurality of hollow fiber membrane portions disposed therebetween. In the plurality of hollow fiber membrane portions, the hollow fiber membranes are yarned in parallel and the membrane filtrating function is exhibited. An outer periphery of the parallel-yarned bundle in the plurality of hollow fiber membrane portions may have a structure of interposing no reinforcement member particularly as shown in Fig. 3, and may have a structure of interposing a reinforcement member (not shown). As the structure of

interposing a reinforcement member, for example, there is a structure of disposing 1 to 30 reinforcing stays (e.g., metal rods) on an outer periphery or inside of the parallel-yarned so that the adhered and fixed portions are connected to each other by the stays, or a structure of disposing a porous plate-shaped material such as a net to cover an outer periphery of a hollow fiber membrane yarned bundle between the adhered and fixed portions. As the stay, there is a cylindrical pole-shaped having a sectional area of 3 mm² to 700 mm² by way of example.

[0031]

In the hollow fiber module according to the invention, an adhered and fixed portion 9a integrally adhered in a state where an end surface of the hollow fiber membranes is opened is formed on the upper end side where a plurality of hollow fiber membranes are bundled, and a water collecting portion formed of a water collecting cap 10 is disposed on the opened end surface of the hollow fiber membranes.

[0032]

An adhered and fixed portion 9b provided on the lower end side of the hollow fiber membrane bundle may have a structure of forming an adhered and fixed portion where a plurality of units of small bundles are adhered and fixed in a state where an end surface of the membranes

is closed. By having the units of such small bundles, it is possible to further improve the performance of discharging suspended substances from the inside of the module. In the adhered and fixed portions formed on the lower end side of the hollow fiber membrane bundle by small bundles, the adhered and fixed small bundles are independent from each other in a non-adhered manner, and there are gaps between the small bundles. The number of small bundles formed on the lower end side of the hollow fiber membrane bundle is preferably 3 to 50 per one membrane module, and the number of hollow fiber membranes forming the small bundles is preferably 50 to 2000.

[0033]

In the membrane filtrating apparatus according to the invention, a ratio of a sectional area of the membrane module to an in-tank sectional area of the submersion tank is a ratio (percentage) of a sectional area of an outer surface 2B of the membrane module to a sectional area of an inner surface 1A of the submersion tank, in a horizontal sectional surface at a height from the upper end portion to the lower end portion of the membrane module 2 disposed in the submersion tank 1, as shown in Fig. 2. When the sectional area of the membrane module 2 or the sectional area of the submersion tank 1 is not constant and a ratio of the sectional area of the membrane

module occupied in the horizontal sectional area of the submersion tank changes by height from the upper end portion to the lower end portion of the membrane module 2 disposed in the submersion tank 1, the maximum value thereof may be a predetermined value in the range of 60% to 90%.

[0034]

The membrane module at the time of defining a ratio of the sectional area of the membrane module to the in-tank sectional area of the submersion tank indicates a portion from one end adhered and fixed portion to the other adhered and fixed portion, and the water collecting cap or an air introducing cylinder belonging to the vicinity thereof is not included. The sectional area of the outer surface 2B of the membrane module from the upper end portion to the lower end portion of the membrane module 2 indicates an area surrounded by the outer peripheral portion in case of the adhered and fixed portions 9a and 9b, and indicates a circumscribed area including the whole of the hollow fiber membranes in case of a portion where the hollow fiber membranes between the adhered and fixed portions are opened. In case where the outer peripheral portion of the hollow fiber membrane bundle between the adhered and fixed portions is covered with a porous plate-shaped member such as a net, the

sectional area indicates an area surrounded by the outer peripheral portion such as the net.

[0035]

In case of disposing a plurality of hollow fiber membrane modules in a submersion tank as shown in Fig. 4, the sectional area indicates a ratio calculated in a manner that an sectional area of the inner surface 1A of the submersion tank is a denominator and the sum of sectional areas of the outer surfaces 2B of the membrane modules is a numerator as shown in Fig. 5.

[0036]

In the invention, an air diffusion pipe 3 for air scrubbing is disposed below the membrane module 2 to discharge suspended substances accumulated in the hollow fiber membrane module out of the membrane module system, but the structure or material is not limited. In the air diffusion pipe 3, air diffusion holes 4 are formed to diffuse compressed air supplied from a blower (not shown) or the like to raw water in the submersion tank 1, but the diameter or the number of the air diffusion holes is not limited.

[0037]

In the invention, a distance between the air diffusion pipe and the bottom of the submersion tank is a distance when a position of the air diffusion holes 4

formed in the air diffusion pipe 3 is represented by a height from the bottom of the submersion tank. In the position of the bottom of the submersion tank, the substantially lowest position of the bottom is a referential position when the bottom has a conical shape as shown in the drawing. When the height of the air diffusion holes 4 changes according to each of the air diffusion holes, the distance indicates a distance from the bottom of the submersion tank to the air diffusion hole located at the lowest position.

[0038]

Next, a membrane filtration operation using the membrane filtrating apparatus including the submerged hollow fiber membrane module with the above-described configuration will be described, and the advantage of the invention will be described.

[0039]

One or hundreds of hollow fiber membrane modules 2 are disposed in the submersion tank 1 according to the conditions such as a treatment amount of water or an area of the submersion tank. In this case, raw water including suspended substances is previously put in the submersion tank 1. When the upper adhered and fixed portion that is adhered and fixed in a state where an end surface of the hollow fiber membranes is opened is pumped by a pump, the

raw water including suspended substances is separated into solid and liquid (filtrated) by the hollow fiber membranes 8, and the filtrated water is sent from the water collecting cap 10 through the permeated water pipe 5 to the water collecting pipe. When the raw water is absorbed and the filtrated water is taken out of the submersion tank, the level of water in the submersion tank is lowered. Accordingly, raw water is intermittently or periodically supplied into the submersion tank as necessary.

[0040]

In this case, in the invention, a raw water supply port 6 is disposed above the membrane module, and a ratio of the sectional area of the membrane module occupied in the in-tank sectional area of the submersion tank is 60% to 90%. For this reason, a considerable amount of suspended substances in raw water go on a descending flow caused by inflow of raw water, pass through gaps between the membrane module 2 and the submersion tank 1 having some spaces or gaps between the plurality of membrane modules, and are precipitated into the bottom of the submersion tank. In the invention, a distance from the air diffusion pipe 3 disposed below the membrane module 2 to the bottom of the submersion tank is 200 mm or more. Accordingly, the suspended substances precipitated lower than the air diffusion pipe are accumulated at a position

lower than the air diffusion pipe without turning around the membrane filtrating surface, and thus it is possible to lower the concentration of the suspended substances around the hollow fiber membranes 8. Therefore, it is possible to prevent block caused by the suspended substances.

[0041]

Some of suspended substances, which are not precipitated, reach the vicinity of the membrane surface of the hollow fiber membranes 8, and are attached to the surfaces of the membranes and the insides of the pores of the membranes. For this reason, when the filtration process is completed at a predetermined time, a cleaning operation (reverse flow cleaning) is performed which allows the filtrated water or the compressed air to flow in a direction from the water collecting cap 10 to the raw water to peel off the suspended substances attached to the insides of the pores of the membranes, and/or a cleaning operation (air scrubbing) is performed which supplies compressed air from the air diffusion holes 4 of the air diffusion pipe 3 disposed lower than the hollow fiber membrane module 2 through an air introducing cylinder 11 disposed below the membrane module and penetration holes 12 of the lower adhered and fixed portion to the hollow fiber membranes 8 to shake the hollow fiber membranes,

peels off the suspended substances attached to the surfaces of the hollow fiber membranes, and discharges the suspended substances from the hollow fiber membranes.

[0042]

Fig. 6 shows flow of water in the submersion tank at the time of performing the air scrubbing in the membrane filtrating apparatus shown in Fig. 1. In the invention, an in-tank space where the membrane module is not installed is secured in a predetermined range so that a ratio of the sectional area of the membrane module 2 occupied in the in-tank sectional area of the submersion tank 1 is 60% to 90%. Accordingly, it is possible to provide a high property of discharging suspended substances clogged between the hollow fiber membranes, which is a merit of the submerged membrane module, and the suspended substances peeled off from the hollow fiber membranes by the reverse flow cleaning and the air scrubbing are promptly discharged out of the membrane module. The peeled-off suspended substances float up in the submersion tank, pass through the gaps between the membranes modules 2 and the inner wall of the submersion tank 1 or the gaps between the plurality of membrane modules, and are precipitated into the bottom of the submersion tank. At this time, a part of the suspended substances are precipitated into a suspended material

accumulation space below the air diffusion pipe, but the other part of the suspended substances move to the vicinity of the surface of the hollow fiber membranes along the flow of air again.

[0043]

In the invention, a distance from the air diffusion pipe 3 disposed below the membrane module 2 to the bottom of the submersion tank is 200 mm or more. Accordingly, water in an area which is below the air diffusion pipe and in which the suspended substances are accumulated and concentrated is not mixed even at the time of the air scrubbing. Therefore, the suspended substances moving into the area which is below the air diffusion pipe and is hardly affected by the air scrubbing do not float again, and do not move to the vicinity of the hollow fiber membranes 8.

[0044]

As describe above, in the membrane filtrating apparatus, it is possible to easily discharge the suspended substances clogged between the hollow fiber membranes at the time of the air scrubbing to the outside thereof and it is possible to precipitate at least a part of the suspended substances below the air diffusion pipe. In addition, the accumulated and concentrated suspended substances that are precipitated to the vicinity of the

bottom of the submersion tank 1 once do not float up again.

[0045]

The membrane filtrating process, the reverse flow cleaning, and the air scrubbing are repeatedly performed, and the suspended substances accumulated and concentrated in the bottom of the submersion tank 1 are regularly discharged from a drain line 7. Accordingly, it is possible to continue a stable membrane filtration operation even with respect to high-turbidity raw water.

[0046]

However, in the submerged hollow fiber membrane module, a plurality of bundled hollow fiber membranes are disposed in the module, and an area of the membranes per unit volume is large. Accordingly, there is a problem that suspended components are easily filled between the membranes. Therefore, even in case of the membrane filtrating apparatus, the suspended substances that are not precipitated in the bottom of the submersion tank and float up stay in the vicinity of the membrane surfaces of the hollow fiber membranes 8, and the concentration of the suspended substances in the vicinity of the hollow fiber membranes becomes high during the operation for a long time. As a result, it is difficult to perform a stable operation.

[0047]

To solve this problem, it is necessary to perform an operation capable of reducing the concentration of the suspended substances in the vicinity of the hollow fiber membranes 8. For example, most or full amounts of water in the submersion tank 1 having a high concentration of the suspended substances are regularly discharged, and instead, a full drain method of flowing relatively clear raw water (raw water having a relatively small amount of suspended substances) is performed. In case of the conventional submerged hollow fiber membrane module, since a volume of the membrane module occupied in a volume of the submersion tank is small, a water return rate (operation return rate) of the filtration operation is largely lowered at the time of performing the full drain method. However, in the invention, since the sectional area of the membrane module 2 occupied in the horizontal sectional area of the submersion tank 1 is 60% to 90%, it is possible to keep an operation return rate high even in case of performing the full drain method.

[0048]

In case of performing the full drain method in the membrane filtrating apparatus according to the invention, the operation may be performed so that a level of water in the submersion tank 1 is lowered at a position lower than the air diffusion pipe 3 by 200 mm or more. In the

membrane filtrating apparatus according to the invention, the suspended substances staying at a position lower than the air diffusion pipe by 200 mm and at a position lower than the position do not float up even by performing the air scrubbing. Accordingly, it is not necessary to replace the water staying lower than the air diffusion pipe by 200 mm or more at the time of performing the full drain. For this reason, the water in the submersion tank is discharged at the time of regularly performing the full drain so that the level of water in the submersion tank is lowered than the air diffusion pipe by 200 mm or more, thereby sufficiently reducing the concentration of the suspended substances in the vicinity of the hollow fiber membranes 8, which meets the purpose of the full drain.

[0049]

Particularly, in case of a submersion tank having a large space in a vertical direction below the hollow fiber membranes, preferably, most or full amounts of the water in the submersion tank are not discharged to reduce excessively discharged water to improve an operation return rate, and the level of water is lowered to a position lower than the air diffusion pipe by 200 mm to 400 mm. When the full drain is performed by the above-described operation method, it is possible to keep an operation return rate high even in the membrane filtrating

apparatus using the submersion tank having the large space in the vertical direction below the hollow fiber membrane module 2.

[0050]

Just before performing the full drain, the quantity of water in the tank upper than the hollow fiber membrane module 2 is reduced as small as possible by adjusting the level of water in the submersion tank, and thus it is possible to keep an operation return rate higher. The air diffusion pipe 3 is disposed at a position as close to the lower end of the hollow fiber membrane module 2 as possible, it is possible to more reduce a displacement at the time of performing the full drain, and thus it is possible to raise an operation return rate.

[0051]

As described above, according to the membrane filtrating apparatus of the invention, it is possible to keep a property of discharging suspended substances clogged between the membranes high, which is a merit of the submerged hollow fiber membrane module, and it is possible to keep an operation return rate high, even when the whole or most of water in the submersion tank is regularly discharged. In addition, since a considerable amount of suspended substances included in the raw water are not filtrated by the membranes and are precipitated in

the bottom of the submersion tank, it is possible to perform a stable membrane filtration operation at a high return rate even with respect to relative high-turbidity raw water.

[0052]

To largely improve an operation return rate while keep the excellent property of discharging suspended substances, it is more preferable that a ratio of the sectional area of the membrane module 2 occupied in the horizontal sectional area of the submersion tank 1 is set to 70% to 80%, and it is more preferable that a distance between the air diffusion pipe 3 and the bottom of the submersion tank is set to 200 mm to 700 mm, in consideration of the point of installation space and construction costs.

[0053]

In the case where a precipitation property of suspended substances in raw water such as a case where a cohesion agent is added to raw water, the amount of the suspended substances floating in the vicinity of the hollow fiber membranes becomes small. Accordingly, it is possible to perform a stable operation at a high return rate by employing an operation method of regularly discharging some of water in the submersion tank without regularly performing the full drain. However, even in

this operation method, as the ratio of sectional area of the membrane module 2 occupied in the horizontal sectional area of the submersion tank 1 is high, the property of discharging suspended substances becomes lower. As the ratio is low, the installation area for the apparatus becomes wider and the costs become higher. Therefore, even in case of performing this operation method, it is effective that the ratio of the sectional area of the membrane module 2 occupied in the horizontal sectional area of the submersion tank 1 is 60% to 90%, and it is preferable that the ratio is set to 70% to 80%. In addition, it is effective that the distance between the air diffusion pipe 3 and the bottom of the submersion tank is 200 mm or more, and it is preferable that the distance is set to 200 mm to 700 mm in consideration of an installation space and construction costs.

Example

[0054]

<Example 1>

A hollow fiber membrane bundle formed of 3500 hollow fiber membranes made of polyvinylidene fluoride having an outer diameter of 1.5 mm, an inner diameter of 0.9 mm, and a length of about 1000 mm was bundled and fixed by urethane-based adhesives in a state where an end surface

of an upper end of the hollow fiber membranes was opened and an end surface of a lower end of the hollow fiber membranes was closed, thereby producing a hollow fiber membrane module having a membrane area of 15 m². As shown in Fig. 3, this membrane module has penetration holes 12 at a lower end adhered and fixed portion, and has a structure in which an air introducing cylinder 11 is provided below the lower end adhered and fixed portion and a water collecting cap 10 is provided above the upper end adhered and fixed portion. A mesh-shaped porous plate made of polyethylene is attached between the upper end adhered and fixed portion and the lower end adhered and fixed portion to surround the outer periphery of the hollow fiber membrane bundle (not shown).

[0055]

One hollow fiber membrane module was disposed in a submersion tank shown in Fig. 1 in a vertical direction. At that time, a ratio of a sectional area of the membrane module occupied in a horizontal sectional area of the submersion tank was 75%, a distance between the air diffusion pipe and the bottom of the submersion tank was 300 mm, and a membrane filtration test was carried out under the following conditions.

[0056]

A filtration process was performed for 30 minutes

using lake water having a turbidity of 2 to 50 as raw water at a membrane filtration flow rate of 0.5 m/day, then a reverse flow cleaning process was performed at a flow rate of 1.0 m/day for 30 seconds by the membrane filtrated water to which sodium hypochlorite of 10 mg/L was added, and an air scrubbing process was performed at an air flow rate of 100 L/Min for 60 seconds. The full amount of water in the submersion tank was discharged once every when the filtration, the reverse flow cleaning, and the air scrubbing were repeated twelve times, and an operation return rate was set to 98%.

[0057]

Although these operations were performed continuously for about one week, it was not observed that a differential pressure between the membranes rises in the course of the test period, and it was possible to continue a stable membrane filtration operation.

[0058]

<Comparative Example>

A hollow fiber membrane module and the like were installed in a submersion tank having a different size so that a ratio of a sectional area occupied in a horizontal sectional area of the submersion tank is 95% and a distance between an air diffusion pipe and the bottom of the submersion tank is 100 mm, using the hollow fiber

membrane module used in Example 1. In the operation conditions, only the number of times of discharging the full amount of water in the submersion tank was changed, and a membrane filtration flow rate, an operation return rate, and the like were set to the same condition. Under these conditions, the same membrane filtration test as that of Example 1 was carried out.

[0059]

As a result, a differential pressure between the membranes was rising at a rate of 1.0 kPa/day.

[0060]

<Comparative Example 2>

A hollow fiber membrane module and the like were installed in a submersion tank having a different size so that a ratio of a sectional area occupied in a horizontal sectional area of the submersion tank is 30% and a distance between an air diffusion pipe and the bottom of the submersion tank is 500 mm, using the hollow fiber membrane module used in Example 1. In the operation conditions, only the number of times of discharging the full amount of water in the submersion tank was changed, and a membrane filtration flow rate, an operation return rate, and the like were set to the same condition. Under these conditions, the same membrane filtration test as that of Example 1 was carried out.

[0061]

As a result, a differential pressure between the membranes was rising at a rate of 1.0 kPa/day.

Industrial Applicability

[0062]

The membrane filtrating apparatus using a submerged hollow fiber membrane module is applicable to sewage disposal and industrial waste water disposal as well as water supply disposal.

Claims

[1] A membrane filtrating apparatus, in which a submerged hollow fiber membrane module formed by bundling a plurality of hollow fiber membranes is disposed in a submersion tank having a raw water supply port at an upper portion thereof and a drain port at a lower portion thereof so that a longitudinal direction of the hollow fiber membranes corresponds to a vertical direction, and an air diffusion pipe is disposed below the hollow fiber membrane module,

wherein the raw water supply port is disposed upper than the hollow fiber membrane module, a ratio of a sectional area of the hollow fiber membrane to an in-tank sectional area of the submersion tank is 60% to 90% in a horizontal section with the hollow fiber membrane module disposed, a distance between the air diffusion pipe and the bottom of the submersion tank is 200 mm or more, and the drain port is disposed lower than the air diffusion pipe by 200 mm or more.

[2] The membrane filtrating apparatus according to Claim 1, wherein a ratio of a sectional area of the hollow fiber membrane to an in-tank sectional area of the submersion tank is 70% to 80% in a horizontal section with the hollow

fiber membrane module disposed, and a distance between the air diffusion pipe and the bottom of the submersion tank is 200 mm to 700 mm.

[3] The membrane filtrating apparatus according to Claim 1, wherein the hollow fiber membrane module has a structure in which a plurality of hollow fiber membranes are bundled at least at an upper end and a lower end thereof, the upper end side of the hollow fiber membrane bundle is bundled and fixed in a state where an end surface of the hollow fiber membranes is opened, a water collecting portion is disposed on the opened end surface of the hollow fiber membranes, and the lower end side of the hollow fiber membrane bundle is bundled by a plurality of small bundles in a state where an end surface of the hollow fiber membranes is closed.

[4] The membrane filtrating apparatus according to Claim 1, wherein the drain port is disposed at the bottom of the submersion tank.

[5] An operation method of filtrating raw water using the membrane filtrating apparatus according to any one of Claims 1 to 4, wherein a level of water in the submersion tank is regularly lowered to a position lower than the air

diffusion pipe by 200 mm or more.

[6] An operation method of filtrating raw water using the membrane filtrating apparatus according to any one of Claims 1 to 4, wherein some of water in the submersion tank is regularly discharged from the drain port.