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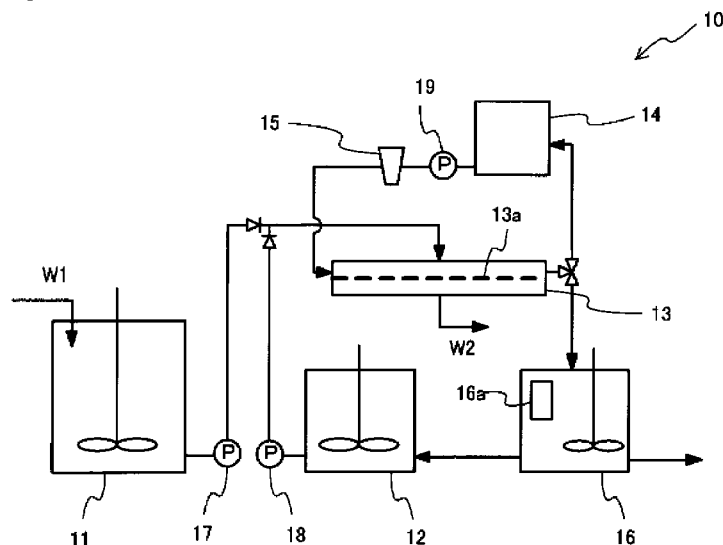
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(54) Title: WATER TREATMENT SYSTEM AND WATER TREATMENT METHOD

[Fig. 1]



(57) Abstract: A water treatment system removing removal target substances contained in raw water as water to be treated has: an aggregate forming mechanism configured to mix the raw water and magnetic particles to form an aggregate containing the removal target substances and the magnetic particles; an aggregate separating mechanism configured to separate the aggregate from the raw water to obtain purified treated water; a disintegrating mechanism configured to apply a centrifugal force to the aggregate separated from the raw water to disintegrate the aggregate; a separating and collecting mechanism configured to separate the magnetic particles obtained by a disintegration of the aggregate by using a magnetic force to collect the magnetic particles; and a reusing mechanism configured to circulate the magnetic particles collected by the separating and collecting mechanism to the aggregate forming mechanism for formation of the aggregate.



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Description

Title of Invention: WATER TREATMENT SYSTEM AND WATER TREATMENT METHOD

Field

[0001] Embodiments described herein relate generally to a water treatment system and a water treatment method.

Background

[0002] Nowadays, effective utilization of water resources is demanded due to development in industry and increase in population. For this purpose, it is crucial to reuse wastewater such as industrial wastewater. In order to achieve them, it is necessary to purify water, that is, separate unwanted substances from water.

[0003] Various methods are known for thus separating unwanted substances from water. For example, there may be mentioned removal of suspended substances by membrane separation, centrifugation, activated carbon adsorption, ozone treatment, aggregation, or filter aid. By such various methods, chemical substances having large influences on environments, such as phosphorous and nitrogen, contained in water can be removed or oils, clays, and the like dispersed in water can be removed.

[0004] In such purification technology, attempts have been made widely to mix magnetic particles into a chemical agent or absorption material to be added and perform separation and collection by using of magnetic force. For example, there are known a technique to add an aggregating agent and a magnetic particles to form a magnetic flock by aggregation of substances to be removed in the water, and removing them with a magnet, a technique to form a filter aid containing magnetic material on a filter to perform filtration, and clean and reuse the filter aid, and the like.

[0005] Then, in such water treatment methods, a technique to reuse the magnetic particles is important. In this case, efficient separation performance of the magnetic particles and the substances to be removed has to be increased, and there are known a method to break the magnetic flock by using a shear force by a magnetic drum and a transportation pump, and a technique to move a magnet in a separation device so as to separate the filter aid containing magnetic material by changes in magnetic field.

Citation List

Patent Literature

[0006] PTL 1: JP-B2 5422516
PTL 2: JP-B2 5389196
PTL 3: JP-B2 5284242

Summary of Invention

Problems to be Solved by the Invention

- [0007] A problem to be solved by the invention is to provide a water treatment system and a water treatment method which, in a water treatment to remove removal target substances from raw water as water to be treated, purify the raw water by using magnetic particles and efficiently separate the used magnetic particles from the removal target substances to make them reusable.

Means for Solving the Problems

- [0008] A water treatment system of an embodiment is a water treatment system removing removal target substances contained in raw water, having: an aggregate forming mechanism configured to mix the raw water and magnetic particles to form an aggregate containing the removal target substances and the magnetic particles; an aggregate separating mechanism configured to separate the aggregate from the raw water to obtain purified treated water; a disintegrating mechanism configured to apply a centrifugal force to the aggregate from the raw water to disintegrate the aggregate; a separating and collecting mechanism configured to separate the magnetic particles obtained by a disintegration of the aggregate by using a magnetic force to collect the magnetic particles; and a reusing mechanism configured to circulate the magnetic particles collected by the separating and collecting mechanism to the aggregate forming mechanism for formation of the aggregate.
- [0009] A water treatment method of this embodiment is a water treatment method removing removal target substances contained in raw water, mixing the raw water and magnetic particles to form an aggregate containing the removal target substances and the magnetic particles; separating the aggregate from the raw water to obtain purified treated water; applying a centrifugal force to the aggregate separated from the raw water to disintegrate the aggregate; separating the magnetic particles obtained by the disintegration by using a magnetic force to collect the magnetic particles; and reusing the magnetic particles obtained by a disintegration of the aggregate for formation of the aggregate to mix the raw water.

Brief Description of Drawings

- [0010] [fig.1]Fig. 1 is a diagram illustrating a schematic structure of a water treatment system according to a first embodiment.
- [fig.2]Fig. 2 is a diagram illustrating a schematic structure of a water treatment system according to a second embodiment.
- [fig.3]Fig. 3 is a diagram illustrating a schematic structure of a water treatment system according to a third embodiment.
- [fig.4]Fig. 4 is a diagram illustrating a schematic structure of a water treatment system according to a fourth embodiment.

[fig.5]Fig. 5 is a diagram illustrating a schematic structure of a system in which a turbidity sensor and a particle size meter are provided in the water treatment system according to the fourth embodiment.

[fig.6]Fig. 6 is a flowchart illustrating a method of adjusting an amount of adding an aggregating agent in the water treatment system of FIG. 5.

[fig.7A]Fig. 7A is a side cross-sectional view illustrating a schematic structure of a liquid cyclone.

[fig.7B]Fig. 7B is an A-A cross-sectional view of the liquid cyclone of FIG. 7A.

Detailed Description

[0011] Hereinafter, an embodiment of the present invention will be described in detail. A water treatment system in this embodiment is, as described above, a water treatment system removing removal target substances contained in raw water, having: an aggregate forming mechanism configured to mix the raw water and magnetic particles to form an aggregate containing the removal target substances and the magnetic particles; an aggregate separating mechanism configured to separate the aggregate from the raw water to obtain purified treated water; a disintegrating mechanism configured to apply a centrifugal force to the separated aggregate to disintegrate the aggregate; a separating and collecting mechanism configured to separate the magnetic particles obtained by a disintegration of the aggregate by using a magnetic force to collect the magnetic particles; and a reusing mechanism configured to circulate the magnetic particles collected by the separating and collecting mechanism to the aggregate forming mechanism for formation of the aggregate.

[0012] Here, the water treatment in this embodiment can be broadly divided into two according to a method of forming an aggregate containing magnetic particles and removal target substances. Specifically, there are a first separation method based on solid-liquid separation and a second separation method based on magnetic separation. The solid-liquid separation is a method to form the aggregate by a filtering operation by using the magnetic particles as a filter aid, and meanwhile obtain the aggregate by peeling it off a filtration surface. The magnetic separation is a method to form the aggregate as a flock having magnetism by using magnetic particles and an aggregating agent, and collect and obtain the aggregate by a magnetic force.

[0013] Note that the removal target substances in this embodiment are suspended substances (SS) contained in the raw water. The suspended substances are generally particulate substances having a diameter of 2 mm or less and floating or being suspended in water, and are difficult to separate because they do not settle naturally by gravity. The suspended substances (SS) may include, for example, organic matters such as water bloom, selenite, and other microorganisms, alumina, iron hydroxide, copper hydroxide, and the like.

[0014] Then, the aggregate obtained as described above is disintegrated into the magnetic particles and the removal target substances by applying a centrifugal force, and the disintegrated magnetic particles are collected by a magnetic force. The collected magnetic particles are reusable for forming the aggregate.

[0015] Hereinafter, the water treatment system and the water treatment method using the above-described separation method will be described in more detail with reference to drawings.

[0016] (First Embodiment)

A water treatment system according to this first embodiment uses the first separation method by solid-liquid separation to obtain an aggregate by peeling off a filtration surface, and FIG. 1 is a diagram illustrating a schematic structure thereof.

[0017] <Water Treatment System>

A water treatment system 10 illustrated in FIG. 1 has a raw water storage tank 11 for storing raw water containing suspended substances as removal target substances, a filter aid storage tank 12 for storing a filter aid containing magnetic material, a filtering device 13 forming an aggregate from the filter aid and the removal target substances and trapping the aggregate on a filtration surface 13a to obtain purified water by solid-liquid separation, a washing water storage tank 14 for storing washing water for washing the aggregate off the filtration surface 13a of the filtering device 13, a centrifugal separator 15 applying a centrifugal force to the washed-off aggregate to disintegrate the aggregate, and a separating and collecting tank 16 storing a disintegrated matter mixed solution containing disintegrated matters obtained by disintegration and having a magnet 16a for separating and collecting disintegrated magnetic particles by a magnetic force.

[0018] Further, this water treatment system 10 is structured to be capable of circulating from the filtering device 13 through the washing water storage tank 14 and the centrifugal separator 15 to the filtering device 13. Further, the magnetic particles separated by the separating and collecting tank 16 are sent to the filter aid storage tank 12, and also circulated to be reusable as the filter aid.

[0019] Here, the raw water storage tank 11 temporarily stores a raw water W1, containing removal target substances as a target of treatment, supplied thereto, and the raw water can be sent to the filtering device 13 at a desired timing by a pump 17.

[0020] The raw water storage tank 11 is not particularly limited in its container shape, capacity, material, and so on as long as the raw water can be stored stably, and is preferred to have a capacity such that a storage time of at least about 15 minutes can be secured. Further, in the raw water storage tank 11, preferably, a shortcut such as a flow of the raw water into a piping leading to the filtering device 13 immediately after it is supplied to the raw water storage tank 11 is prevented by providing a baffle plate, or

the like.

- [0021] Here, as the raw water, one containing suspended substances as the removal target substances in this embodiment can be applied. As this raw water, generally, there may be mentioned industrial wastewater generated in washing steps in product manufacturing processes in general industries, such as electronic part manufacturing industries, machining industries, and food processing industries, polishing agent wastewater, cutting chip wastewater, wastewater containing metal in which metals are precipitated under conditions of alkali or the like, such as plating wastewater, and the like.
- [0022] The filter aid storage tank 12 temporarily stores magnetic particles as the filter aid. And when in use, it is used to supply the filter aid to the filtration surface 13a of the filtering device 13, which will be described later, so as to deposit the filter aid on the surface of the filtration surface 13a to form a precoat layer. Here, in the filter aid storage tank 12, the magnetic particles may be stored as a mixed solution with pure water or the like so as to allow supply to the filtering device 13. This mixed solution containing the filter aid can be sent to the filtering device 13 by a pump 18.
- [0023] Note that in the water treatment system 10 of FIG. 1, to send liquid from the filter aid storage tank 12 to the filtering device 13, a piping provided with a one-way valve is connected to a middle point of a supply piping which supplies the raw water from the raw water storage tank 11 to the filtering device 13. Thus, the raw water or the filter aid can each be supplied to the filtering device 13 by the same piping. However, an independent filter aid supply pipe may be provided separately from the supply piping of the raw water to supply the filter aid to the filtering device 13.
- [0024] Here, the magnetic particles as the filter aid may be any magnetic particles as long as they are able to form the aggregate with the removal target substances by filtration, and are not particularly limited as long as magnetic materials contained in the particles. As this magnetic particles, for example, there may be mentioned iron, alloy containing iron, magnetite, ilmenite, pyrrhotite, magnesia ferrite, manganese-magnesium ferrite, manganese zinc ferrite, cobalt ferrite, nickel ferrite, nickel zinc ferrite, barium ferrite, or copper zinc ferrite. By constituting the filter aid from the particles made of magnetic material, recovery of the filter aid, which will be described below, can be simply performed by using a magnetic force.
- [0025] Among the above-described particles, magnetic particles containing a ferrite-based compound excellent in stability in water are more preferred. For example, a magnetite (Fe_3O_4), which is a magnetic iron ore, is not only inexpensive but also stable as a magnetic particles in water and also safe as an element, and hence is preferred since it can easily be used for water treatment.
- [0026] In this case, the above-described particles can take various shapes such as sphere,

polygon, and irregular, but are not particularly limited. Further, desired particles and shapes may be selected appropriately in consideration of manufacturing costs and the like.

[0027] The size of the filter aid changes in optimum range due to conditions such as density of magnetic particles and various conditions besides magnetic force, flow rate, and trapping method of the processing facility. However, the average particle diameter of the magnetic particles in this embodiment is generally 0.1 micro meter to 100 micro meter, preferably in the range of 0.3 micro meter to 50 micro meter. When the lower limit value of the average particle diameter is smaller than 0.1 micro meter, the magnetic particles aggregate densely to be able to remove minute suspended substances (SS) in water, but a water passing rate sufficient for practical use may not be obtained in some cases. When the upper limit value of the average particle diameter is larger than 100 micro meter, the distance among particles becomes large and the suspended substances (SS) to be removed in water cannot be removed sufficiently in some cases.

[0028] Note that the average particle diameter of the magnetic particles can be measured by laser diffractometry and may be measured, specifically, with a SALD-3100 measurement apparatus (trade name) made by Shimadzu Corporation. Note that in this specification, the term "average particle diameter" means a volume-based 50% integrated value (D_{50}) in particle size distribution measured by laser diffractometry as one mentioned above unless described otherwise.

[0029] Moreover, the whole filter aid need not be constituted of magnetic material. That is, the magnetic particles as the filter aid, even when including the magnetic material in a part thereof, may contain other substances as long as magnetic separation is possible in a separating and collecting step, which will be described later, by operation of the magnetic force on these magnetic particles. The magnetic particles containing the other substances may be particles bonded by a binder, such as styrene resin, hydrogenated styrene resin, butadiene resin, isoprene resin, acrylonitrile resin, cycloolefin resin, phenol resin, alkylmethacrylate resin, fluorocarbon resin, or the like, or particles with a coated surface by the binder. Further, they may be magnetic particles having a surface modified with an alkoxysilane compound such as methyltrimethoxysilane, methyltriethoxysilane, phenyltrimethoxysilane, or phenyltriethoxysilane.

[0030] By using the magnetic particles with a processed surface as the filter aid, when a precoat layer, which will be described later, is formed by using this filter aid, this precoat layer can be formed to have an appropriate gap. Accordingly, the suspended substances in water can be sufficiently trapped and removed, and a sufficient passing water rate can be secured.

[0031] The filtering device 13 is a filtering device having the filtration surface 13a. On this

filtration surface 13a, the precoat layer by magnetic particles are formed in advance. When raw water containing the removal target substances are supplied to the filtration surface 13a on which the precoat layer is formed, the removal target substances are trapped in the precoat layer on the filtration surface 13a, thereby forming an aggregate containing the magnetic particles and the removal target substances. Then, at the same time the aggregate is formed thus, the removal target substances are removed as the aggregate from the raw water, thereby obtaining purified treated water W2. This treated water W2 can be used for various purposes as purified water. Specifically, in this embodiment, the filtering device 13 combines two functions of an aggregate forming mechanism and an aggregate separating mechanism.

- [0032] Note that the treated water W2 obtained here is not illustrated but can be used as washing liquid or water for forming slurry in the water treatment system 10. For example, a piping to supply part of the obtained treated water W2 to the washing liquid storage tank 14, which will be described later, can be provided to use the water as washing water. Further, a piping to supply part of the obtained treated water W2 to the magnetic particle storage tank 12 or the separating and collecting tank 16, which will be described later, can be provided to mix the magnetic particles and collected magnetic particles in each of the tanks to make slurry, making it transportable through the piping to allow smooth proceeding of the treatment.
- [0033] Note that installing the filtering device 13 so that its filtration surface 13a is horizontal is preferred in that the precoat layer constituted of the filter aid can be formed as an even layer on the surface of the filtration surface 13a, and that stable water amount and water quality can be obtained.
- [0034] The washing water storage tank 14 is a tank for storing washing water supplied for peeling and removing the aggregate after filtration from the filtration surface 13a in the filtering device 13. The washing water stored here can be supplied to the filtering device 13 via the centrifugal separator 15, which will be described later, by a pump 19, and this washing water is for peeling and removing from the filtration surface 13a the aggregate in a layer form formed on the filtration surface 13a of the filtering device 13. In order to allow effective peeling by the washing water, the washing water supplied to the filtering device 13 is preferably able to be supplied at angles close to horizontal to the filtration surface 13a.
- [0035] Further, after the aggregate is peeled from the filtration surface 13a by washing, this washing water storage tank 14 may store the aggregate mixed solution containing the aggregate once before it is disintegrated. At this time, the aggregate mixed solution can be stored once and be supplied to the centrifugal separator 15, which will be described later, at a desired timing.
- [0036] The centrifugal separator 15 operates a centrifugal force to the aggregate in the

aggregate mixed solution obtained by cleaning of the filtering device 13, and disintegrate the aggregate into the magnetic particles and the removal target substances. Here, as the centrifugal separator 15, a publicly known centrifugal separator can be used, and it is preferred to be a liquid cyclone since it is able to efficiently disintegrate the aggregate, has a simple device structure, and allows easily subjecting the disintegrated aggregate to the next step. A schematic structure of the liquid cyclone is illustrated in FIGS. 7A, 7B. When liquid is introduced from a liquid conduit 153 provided in a tangential direction of this liquid cyclone, the water diverges to slurry having a large solid content discharged from a bottom nozzle 154 and slurry having a small solid content discharged from a top nozzle 155. By mixing the slurry again the centrifugal force can be operated without performing solid-liquid separation, and a mixed solution in which the aggregate is disintegrated can be obtained.

[0037] The mixed solution containing the disintegrated matter is sent to the separating and collecting tank 16, which will be described next, through the same piping as the washing liquid and via the side of the raw water of the filtering device 13. Whether to send it to the washing liquid storage tank 14 or the separating and collecting tank 16 from the filtering device 13 can be switched at a desired timing with a three-way valve provided on the piping on the discharge side of the washing water. Note that in FIG. 1, the disintegrated matter mixed solution is sent to the separating and collecting tank 16 via the filtering device 13, but may be sent directly from the centrifugal separator 15 to the separating and collecting tank 16.

[0038] Next, the separating and collecting tank 16 accommodates the disintegrated matter mixed solution disintegrated into the magnetic particles and the removal target substances by the centrifugal separator 15, and collects the magnetic particles from the disintegrated matter mixed solution by a magnetic force. For collecting the magnetic particles, a stirrer and a magnet 16a along a side face are provided in the separating and collecting tank 16.

[0039] The magnet 16a may be any one as long as capable of separating and collecting the magnetic particles from the mixed solution by a magnetic force, and may be, for example, an electromagnet, a permanent magnet moved by an air cylinder, or the like. The permanent magnet moved by an air cylinder is such that a permanent magnet having a sheath pipe is prepared, and this permanent magnet is moved up and down with an air cylinder or the like relative to the sheath pipe, thereby generating and releasing a magnetic field on the surface of the sheath pipe to enable separation.

[0040] Moreover, there is provided a piping to send the magnetic particles collected by the separating and collecting tank 16 to the filter aid storage tank 12. Thus, a circulation passage enabling reuse is formed. At this time, upon reuse of the magnetic particles, a washing mechanism configured to wash the magnetic particles may be provided before

sending liquid to the filter aid storage tank 12.

[0041] <Water Treatment Method>

Next, the water treatment method using the water treatment system 10 of FIG. 1 will be described. First, slurry of filter aid and water is adjusted in the filter aid storage tank 12. In addition, to adjust the filter aid in a slurry form, a stirrer provided in the filter aid storage tank 12 is appropriately used.

[0042] Next, the filter aid is supplied to the filtration surface 13a of the filtering device 13 from the filter aid storage tank 12 by the pump 18, and forms the precoat layer constituted of the filter aid on the filtration surface 13a. The filtration surface is generally a filter, and a filter cloth or the like can be used for example.

[0043] Note that for forming the precoat layer, the opening of the filtration surface 13a is set to a size such that the filter aid does not pass the filtration surface 13a. Further, the thickness of the precoat layer is not limited in particular as long as suspended substances in the raw water are trapped and removed. This precoat layer is provided appropriately according to a desired operation, and the thickness thereof depends on the size and a porosity and the like of the filter aid and can be, for example, 0.1 mm to 10 mm.

[0044] Next, the raw water containing the suspended substances (SS) as removal target substances is introduced into the raw water storage tank 11. Thereafter, the raw water is stirred by the stirrer as necessary to disperse the suspended substances in the raw water evenly, and then the raw water is supplied to the filtering device 13 by the pump 17. At this time, since the precoat layer is formed in advance as described above, the raw water is actually supplied to the precoat layer formed on the filtration surface 13a.

[0045] At this time, the suspended substances contained in the raw water are trapped and removed by the filter aid constituting the precoat layer. In the case of this removal, the aggregate of the filter aid and the removal target substances is formed. The water which passed through the precoat layer and the filtration surface 13a of the filtering device 13 is discharged as treated water W2 to the outside through the piping on the side of the treated water of the filtering device 13.

[0046] In this filtering device 13, when used for a predetermined time through a continuous filtering operation, the amount of trapped suspended substances in the raw water in the filter aid constituting the precoat layer increases, clogging by the suspended substances occurs, and a filtration flow amount decreases. Accordingly, cleaning is performed before the filtration flow amount decreases thus. This cleaning may be controlled at a predetermined timing while monitoring a filtering time, a passing water pressure, a passing water amount, a filtration flow rate, and/or the like. For example, when it is controlled by a filtration flow rate, the cleaning may be performed when the filtration flow rate passing through the precoat layer and the filtration surface 13a becomes 2 m/

h or less.

[0047] This cleaning operation is performed by supplying cleaning water on the side of the raw water of the filtering device 13 from the washing water storage tank 14 via a washing water supply line. The cleaning water peels the aggregate constituting part or all of the precoat layer, returns it again as the aggregate mixed solution to the washing water storage tank 14, and moreover, the aggregate mixed solution is circulated to the filtering device 13 from the washing water supply line via the centrifugal separator 15.

[0048] At this time, when the aggregate mixed solution passes through the centrifugal separator 15, an intense shear force operates on the aggregate contained in the aggregate mixed solution, thereby disintegrating the filter aid and the removal target substances constituting the aggregate in pieces. Thus, by introducing the centrifugal separator 15 to the washing water supply line, when cleaning of the filtration surface 13a is performed by a nozzle (not illustrated) for example, the cleaning operation can be performed without causing clogging in a nozzle tip by containing coarse aggregates.

[0049] After the above cleaning operation is finished, the three-way valve is switched so that the cleaning liquid (disintegrated matter mixed solution) containing the disintegrated aggregate flows from the filtering device 13 to the separating and collecting tank 16 side, and thereby the liquid is accommodated in the separating and collecting tank 16.

[0050] In the separating and collecting tank 16, the filter aid as magnetic particles is separated and collected from the disintegrated matter mixed solution by using the magnet 16a (electromagnet or permanent magnet moved by an air cylinder), thereby discharging condensate containing the removal target substances in high concentration. At this time, since the magnetic particles and the removal target substances are separated in advance by the centrifugal separator 15, the magnetic particles can be collected smoothly. Thereafter, the magnetic particles are separated by releasing the magnetic field of the magnet 16, preparing slurry thereof by using part of the treated water W2 or separately prepared pure water or the like, and then the magnetic particles are sent (circulated) to the filter aid storage tank 12. This slurry solution is supplied again from the filter aid storage tank 12 to the filtering device 13, to be reused for forming the precoat layer.

[0051] Then, after the precoat layer is formed, as described above, formation of aggregate (trapping and removal of suspended substances) by supplying the raw water onto the precoat layer, cleaning of the aggregate, disintegration of the aggregate and separation and collection of the filter aid, and so on are performed. By performing this operation repeatedly, treated water purified by continuously and efficiently performing removal of the suspended substances in the raw water can be obtained.

[0052] (Second Embodiment)

A water treatment system according to this second embodiment uses the first

separation method by solid-liquid separation to obtain an aggregate by peeling off a filtration surface, and FIG. 2 is a diagram illustrating a schematic structure thereof.

[0053] A water treatment system 20 illustrated in FIG. 2 has a raw water storage tank 11 for storing raw water containing suspended substances as removal target substances, a filter aid storage tank 12 for storing a filter aid containing magnetic material, a filtering device 13 forming an aggregate from the filter aid and the removal target substances and trapping the aggregate on a filtration surface 13a to obtain purified water by solid-liquid separation, a washing water storage tank 14 for storing washing water for washing the aggregate off the filtration surface 13a of the filtering device 13, a centrifugal separator 15 applying a centrifugal force to the washed-off aggregate to disintegrate the aggregate, and a separating and collecting tank 16 storing a disintegrated matter mixed solution containing disintegrated matters obtained by disintegration and having a magnet 16a for separating and collecting disintegrated magnetic particles by a magnetic force.

[0054] The overall structure of this water treatment system 20 is similar to that illustrated in FIG. 1 in the first embodiment. Thus the same components as those in the first embodiment are omitted from the description, and differences therefrom will mainly be described below. Further, the same reference numerals are used for similar or same components as the components illustrated in FIG. 1.

[0055] In this embodiment, the elements constituting the water treatment system are substantially the same as the first embodiment as described above. A difference is that a piping is provided and structured to supply the filter aid not to the filtering device 13 but to the raw water storage tank 11 by a pump 21 from the filter aid storage tank 12.

[0056] With such a system structure, in the water treatment method in this embodiment, supply is performed from the filter aid storage tank 12 of the water treatment system 20 to the raw water storage tank 11 via the pump 21, magnetic particles as the filter aid and removal target substances contained in raw water are mixed in the raw water storage tank 11, and this mixed solution is supplied to the filtering device 13 by the pump 17, so as to perform filtering by the filtration surface 13a. Such filtration method is called a body feed method, and is effective when the concentration of the suspended substances (SS) in the raw water is high. The filter aid is supplied directly to the raw water and mixed therein, and is then supplied to the filtration surface, thereby decreasing cake resistance due to clogged cakes, allowing to take the filtration amount larger and the filtering time longer.

[0057] The magnetic particles and the removal target substances filtered thus in the filtering device 13 form an aggregate on the filtration surface 13a similarly to the first embodiment, and purified treated water W2 is obtained. The treatment thereafter is exactly the same as the first embodiment, peeling and washing the aggregate from the

filtration surface 13a with purified water supplied from the washing water storage tank 14, and disintegrating it in the centrifugal separator 15, thereafter accommodating it in the separating and collecting tank 16, so as to collect the magnetic particles with the magnet 16a. The collected magnetic particles are made into slurry, sent to the filter aid storage tank 12, and supplied as the filter aid again to the raw water storage tank 11 and reused.

[0058] Note that although the aggregate is obtained by the precoat method in the first embodiment or the body feed method in the second embodiment, these methods may be combined to perform the solid-liquid separation treatment.

[0059] (Third Embodiment)

A water treatment system according to this third embodiment uses the first separation method by solid-liquid separation to obtain an aggregate by peeling off a filtration surface, and FIG. 3 is a diagram illustrating a schematic structure thereof.

[0060] A water treatment system 30 illustrated in FIG. 3 has a raw water storage tank 11 for storing raw water containing suspended substances as removal target substances, a filter aid storage tank 12 for storing a filter aid containing magnetic material, a filtering device 13 forming an aggregate from the filter aid and the removal target substances and trapping the aggregate on a filtration surface 13a to obtain purified water by solid-liquid separation, a washing water storage tank 14 for storing washing water for washing the aggregate off the filtration surface 13a of the filtering device 13, a centrifugal separator 15 applying a centrifugal force to the washed-off aggregate to disintegrate the aggregate, and a separating and collecting tank 16 storing a disintegrated matter mixed solution containing disintegrated matters obtained by disintegration and having a magnet 16a for separating and collecting disintegrated magnetic particles by a magnetic force.

[0061] The overall structure of this water treatment system 30 is similar to that illustrated in FIG. 1 in the first embodiment. Thus the same components as those in the first embodiment are omitted from the description, and differences therefrom will mainly be described below. Further, the same reference numerals are used for similar or same components as the components illustrated in FIG. 1.

[0062] In this embodiment, elements constituting the water treatment system are the same as the first embodiment as described above. A structure different from the first embodiment is that the centrifugal separator 15 is disposed not in the circulation line of the filtering device 13 and the washing water storage tank 14, but in the circulation line discharging from the separating and collecting tank 16 and returning again to the separating and collecting tank 16 by the pump 31. This circulation line may be structured such that a three-way valve is provided in the discharge line of liquid to be accommodated in the separating and collecting tank 16, thereby enabling to switch

between a piping for discharging as it is and a piping for returning to the separating and collecting tank 16. Note that since the disposed position of the centrifugal separator 15 is changed as described above, in the water treatment system 30, the piping to send the washing water containing the aggregate from the filtering device 13 to the washing water storage tank 14 is not provided.

[0063] With such system structure, in the water treatment method in this embodiment, by the washing water supplied from the washing water storage tank 14, the aggregate is peeled off the filtration surface 13a and washed, similarly to the first embodiment, to thereby obtain slurry (aggregate mixed solution) containing the aggregate, and this aggregate mixed solution is sent to the separating and collecting tank 16 to be accommodated therein.

[0064] The aggregate mixed solution contained in the separating and collecting tank 16 is sent to the circulation line which returns again to the separating and collecting tank 16 by the pump 31. At this time, when the aggregate mixed solution passes through the centrifugal separator 15 provided in the circulation line, an intense shear force can operate on the aggregate contained in the mixed solution, disintegrating the aggregate into the magnetic particles and the removal target substances as components thereof.

[0065] With an apparatus structure similar to this embodiment, a purification treatment by filtration using a new filter aid can be performed simultaneously while performing the separating and collecting operation of magnetic particles as the filter aid used for the filtering operation. Accordingly, the filtering time can be secured without being affected by the separation and collection of the filter aid in the water treatment system, enabling to perform an efficient filtering operation. In particular, for suspended substances (SS) which are difficult to remove, a long time is often needed for filtration, and hence the mode of this embodiment is preferred.

[0066] Note that also in this embodiment, the solid-liquid separation by the filtering operation may be performed either by the body feed method or by combined use of the precoat method and the body feed method.

[0067] (Fourth Embodiment)

A water treatment system according to this fourth embodiment uses the second separation method by magnetic separation to obtain an aggregate by collection using a magnetic force, and FIG. 4 is a diagram illustrating a schematic structure thereof.

[0068] <Water Treatment System>

A water treatment system 40 illustrated in FIG. 4 has a flock forming tank 41 for mixing raw water containing suspended substances as removal target substances, magnetic particles and an aggregating agent so as to form a flock (aggregate) having magnetism, a magnetic particle storage tank 42 for storing magnetic particles containing magnetic material, an aggregating agent adding mechanism 43 configured

to add the aggregating agent to the flock forming tank 41, a flock separating tank 44 accommodating a flock formed in the flock forming tank 41 and having magnets 44a for magnetically separating the flock by a magnetic force, a washing water storage tank 14 for storing washing water for washing off the flock separated in the flock separating tank 44, a centrifugal separator 15 applying a centrifugal force to the washed-off flock to disintegrate the flock, and a separating and collecting tank 16 storing a disintegrated matter mixed solution containing disintegrated matters obtained by disintegration and having a magnet 16a for separating and collecting disintegrated magnetic particles by a magnetic force.

[0069] This water treatment system 40 is structured substantially the same as the second embodiment in that magnetic particles are sent by the pump 21 to the flock forming tank 41 to which raw water W1 is supplied from the magnetic particle storage tank 42, and substantially the same as the third embodiment in that the centrifugal separator 15 is disposed in the circulation line discharging from the separating and collecting tank 16 and sending to the separating and collecting tank 16 by the pump 31. Further, it is structured substantially the same as the first to third embodiments in that there is the washing water storage tank 14 for storing washing water for washing the aggregate, and in that the magnetic particles separated in the separating and collecting tank 16 are sent to the magnetic particle storage tank 42 and are circulated to make them possible to be reused as the magnetic particles.

[0070] On the other hand, this embodiment is different from the first to third embodiments in that the aggregate is obtained by forming the flock by using the aggregating agent and that separation of the aggregate is performed by magnetic separation. Accordingly, the flock forming tank 41 and the aggregating agent adding mechanism 43 involved in formation of flock and the flock separating tank 44 magnetically separating the flock are characteristic components.

[0071] Note that the basic concept is the same in all the embodiments. The basic concept is that after the aggregate containing the magnetic particles and the removal target substances is formed and a purification treatment of water is performed, the aggregate is disintegrated, and the magnetic particles are separated and collected to enable reuse of them.

[0072] As described above, the overall structure of the water treatment system 40 is similar to those illustrated in FIG. 1 to FIG. 3 in the first to third embodiments. Thus, the same or similar components are omitted from the description, and differences thereof will mainly be described below. Further, the same reference numerals are used for similar or same components as the components illustrated in FIG. 1 to FIG. 3.

[0073] First, the flock forming tank 41 is a place where the supplied raw water W1 is accommodated, and moreover, the magnetic particles and the aggregating agent are

supplied and mixed, so as to form the flock (aggregate) containing both the removal target substances and the magnetic particles. The magnetic particles are supplied from the magnetic particle storage tank 42 by the pump 21. Further, the aggregating agent just needs to be added to the raw water simultaneously as the magnetic particles, and may be directly charged into the flock forming tank 41 or accommodated in the tank as a solution containing the aggregating agent, similarly to the magnetic particles, allowing charging into the flock forming tank 41 by a predetermined amount at a predetermined timing.

- [0074] The aggregating agent adding mechanism 43 accommodates the aggregating agent and adds a predetermined amount of the aggregating agent at a predetermined timing to the flock forming tank 41. The amount and timing of adding the aggregating agent may be determined appropriately so that the purification efficiency of the raw water becomes good according to the concentration of the removal target substances contained in the raw water W1, strength of the formed flock, turbidity of the treated water, and the like.
- [0075] The flock separating tank 44, to which the raw water containing the flock formed in the flock forming tank 41 is sent by the pump 17, is for accommodating the raw water. This flock separating tank 44 is provided with magnets 44a to enable magnetic separation of the flock in the raw water. As the magnets 44a here, the same one as the magnet 16a described in the first embodiment can be applied.
- [0076] Further, a piping on the discharge side of this flock separating tank 44 is provided with a three-way valve which can switch between a line to obtain purified treated water W2 and a line to send the separated flock by cleaning to the separating and collecting tank 16.
- [0077] The other components exhibit the same functions and operations as those in the first to third embodiments except that the aggregate is the flock.
- [0078] For example, the magnetic particle storage tank 42 accommodates the magnetic particles, which can be supplied to the flock forming tank 41 by the pump 21 at a predetermined timing, and this point is the same as the mode of supplying the filter aid from the filter aid storage tank 12 to the raw water storage tank 11 in the second embodiment.
- [0079] Further, the washing water storage tank 14 accommodates the washing water, which can be supplied to the flock separating tank 44 by the pump 19 to wash off the magnetically separated flock. The washing water containing the washed-off flock is sent to the separating and collecting tank 16 by the three-way valve.
- [0080] The separating and collecting tank 16 accommodates the sent flock-containing washing water, which can be discharged once from the separating and collecting tank 16 and circulate and return again to the separating and collecting tank 16 by the pump

31. Note that the centrifugal separator 15 is provided in this circulation line, and the centrifugal separator 15 disintegrates the flock into the magnetic particles and other components (the removal target substances and the aggregating agent). The disintegrated magnetic particles are separated and collected by the magnet 16a, the magnetic particles obtained thus can be returned to the magnetic particle storage tank 42, enabling circulation and reuse of the magnetic particles. In this separating and collecting tank 16, the aggregate is just changed to the flock of this embodiment, and the other is the same as the third embodiment.

[0081] <Water Treatment Method>

Regarding the water treatment method of this embodiment, characteristic parts different from other embodiments will be described.

[0082] First, the raw water W1 is supplied to the flock forming tank 41 and accommodated therein, and to this raw water, the magnetic particles from the magnetic particle storage tank 42 and the aggregating agent from the aggregating agent adding mechanism 43 are added and mixed in. By mixing and stirring them, there is formed a flock having magnetism in which suspended substances (SS) as the removal target substances contained in the raw water and the magnetic particles are aggregated by the aggregating agent.

[0083] The formed flock having magnetism is sent from the flock forming tank 41 to the flock separating tank 44 by the pump 17. Inside the flock separating tank 44 the magnets 44a are provided, and the flock in the raw water accommodated in the flock separating tank 44 is separated and removed by the magnets 44a, thereby obtaining purified treated water W2.

[0084] Thereafter, the washing water is supplied from the washing water storage tank 14 and the magnetic fields of the magnets 44a are released, to thereby make slurry containing a flock which is concentrated (flock mixed solution). The three-way valve is switched so that the slurry is sent to the separating and collecting tank 16 and accommodated therein.

[0085] The flock mixed solution accommodated in the separating and collecting tank 16 is sent to the circulation line which returns again to the separating and collecting tank 16 by the pump 31. At this time, when the flock mixed solution passes through the centrifugal separator 15 provided in the circulation line, an intense shear force can operate on the flock contained in the mixed solution, disintegrating the flock into the magnetic particles and other components (the removal target substances and the aggregating agent) as components thereof.

[0086] In the slurry (disintegrated matter mixed solution) containing the disintegrated matters disintegrated as described above, the magnetic particles are separated and collected from the disintegrated matter mixed solution by using the magnet 16a

(electromagnet or permanent magnet moved by an air cylinder), thereby discharging condensate containing the removal target substances in high concentration. At this time, since the magnetic particles and the removal target substances are separated in advance by the centrifugal separator 15, the magnetic particles can be collected smoothly. Thereafter, the magnetic particles are separated by releasing the magnetic field of the magnet 16a, preparing slurry thereof by using part of the treated water W2 or separately prepared pure water or the like, and then the magnetic particles are sent (circulated) to the magnetic particle storage tank 42. This slurry solution is supplied again from the magnetic particle storage tank 42 to the flock forming tank 41, to be reused for forming the flock having magnetism.

[0087] Note that the magnetic particles used in this embodiment are not limited in particular as long as they are able to be taken into a flock to form the flock together with the above components when the flock is formed by the removal target substances and the aggregating agent, and as long as they have magnetic material in their particles. As the magnetic particles, magnetic particles similar to the filter aid used in the first to third embodiments can be used. Note that for forming the flock, as the magnetic particles, the filter aid may contain the magnetic material used in the first to third embodiments, and an average particle diameter of the magnetic particles in this embodiment is preferably in the range of 0.1 micro meter to 100 micro meter. When the lower limit value of the average particle diameter is smaller than 0.1 micro meter, there is a concern that the collecting time becomes longer by the magnet 16, deteriorating the treatment efficiency. When the upper limit value of the average particle diameter is larger than 100 micro meter, the settling speed of the magnetic particles is too high, and there is a concern that the flock containing a uniform magnetic particles cannot be formed in the flock forming tank 41.

[0088] Further, in this embodiment, the aggregating agent is added to the raw water besides the magnetic particles to cause the removal target substances in the water and the magnetic particles to aggregate and become a flock having magnetism. As the aggregating agent used at this time, publicly known aggregating agents may be mentioned. As the aggregating agent, there may be mentioned inorganic-based aggregating agents and organic-based aggregating agents. As the inorganic-based aggregating agents, for example, there may be mentioned polyaluminum chlorides, ferric sulfates, ferric chlorides, aluminum sulfates, and the like. Further, the organic-based aggregating agents are divided into anionic polymers, cationic polymers, and nonionic polymers, and there may be mentioned polyacrylamides, polyacrylic esters, polyamidines, polyamines, polyacrylamides, and the like.

[0089] Note that in this embodiment, the amount of adding and the timing of adding the aggregating agent are determined according to water quality of the raw water W1,

strength of the flock to be obtained, turbidity of the treated water, and the like so as to perform the purification treatment of water, but the amount of adding the aggregating agent may be controlled by adjusting while monitoring the water quality of the treated water W2 obtained by the purification treatment and the particle size of the separated flock, and the like.

[0090] For controlling the amount of adding the aggregating agent in this manner, for example, as illustrated in FIG. 5, the control can be performed by providing a turbidity sensor 51 which can measure turbidity of the treated water W2 obtained from the flock separating tank 44, and a particle size meter 52 in a front stage of the centrifugal separator 15 in the circulation line provided in the separating and collecting tank 16. Here, FIG. 5 is a diagram illustrating a schematic structure of a water treatment system 50 in which the turbidity sensor 51 and the particle size meter 52 are provided additionally in the water treatment system illustrated in FIG. 4, enabling to control the amount of adding the aggregating agent according to measurement results thereof.

[0091] The control of the amount of adding the aggregating agent can be performed according to, for example, the flowchart illustrated in FIG. 6. Specifically, as the water treatment is started, first, the aggregating agent of a set amount is added (S1), and the purification treatment is performed. At this time, turbidity of the treated water W2 obtained by the purification treatment is measured by the turbidity sensor 51, and moreover, the particle size before disintegration of the separated flock is measured by the particle size meter 52, thereby monitoring the water quality constantly.

[0092] First, the water quality of the treated water W2 is measured by the turbidity sensor 51, and it is judged whether or not the value of the measured turbidity is equal to or less than a prescribed value set in advance (S2). Here, when the value of the measured turbidity is equal to or less than the prescribed value, the particle size of the flock is measured by the particle size meter 52, and it is judged whether or not the value of the measured particle size is equal to or less than a prescribed value set in advance (S3).

[0093] When both the turbidity and the particle size are equal to or less than the prescribed values, the water quality of the treated water W2 and the formation state of the flock have no problem, and it is further judged whether the water treatment should be continued or not (S4). When the water treatment is continued, the aggregating agent is added again to the raw water W1 at a predetermined timing without changing the amount of adding the aggregating agent (S1), and moreover the judgments of S2 to S4 are repeated to continue the water treatment.

[0094] Further, when the measured value exceeds the prescribed value in the judgment of turbidity (S2), the water quality of the treated water W2 is low, meaning that it is unable to sufficiently remove the removal target substances contained in the raw water W1. Therefore, in this case, the amount of adding the aggregating agent is increased,

and the aggregating agent is added again so that the removal target substances in the raw water sufficiently aggregate to form the flock.

[0095] Further, when the measured value exceeds the prescribed value in the judgment of the particle size (S3), this means that coarse particles exist, that is, the flock to be formed is too large. In this case, the amount of adding the aggregating agent is decreased, and the aggregating agent is added again so that the flock to be formed does not become too large.

[0096] Disintegration Conditions of Aggregate

Note that in the disintegrating steps of the first to fourth embodiments, it is just necessary to use one capable of disintegrating the magnetic particles in the aggregate in a reusable form, and as the one that operates the centrifugal force to the aggregate, a liquid cyclone is preferred as described above. The liquid cyclone, as illustrated in FIG. 7A and FIG. 7B, has a cylindrical part 151 provided in an upper part and an inverted conical base 152 connected to a lower end of the cylindrical part, and the cylindrical part 151 has a liquid conduit 153 introducing liquid in a tangential direction when seen in a plan view.

[0097] When the aggregate mixed solution is introduced from the liquid conduit 153, the centrifugal force operates on the aggregate in the aggregate mixed solution, and the aggregate disintegrates. The disintegrated aggregates are disposed such that ones larger in specific gravity and particle diameter are located closer to the side of a peripheral wall, and ones smaller in specific gravity and particle diameter are located closer to a center side. At this time, a downward flow occurs along a taper of the cyclone in a peripheral wall part, and the ones larger in specific gravity and particle diameter go with this flow and are guided to a bottom nozzle 154. On the other hand, an upward flow occurs inversely in the center part, and ones smaller in specific gravity and particle diameter go with this flow and are discharged to a top nozzle 155. Note that in this embodiment, solutions discharged from the bottom nozzle 154 and the top nozzle 155 are finally mixed and returned to the separating and collecting tank 16 as a disintegrated matter mixed solution containing disintegrated matters obtained by disintegrating the aggregate into the magnetic particles and the removal target substances.

[0098] Note that at this time, preferably, when a flow rate of the aggregate mixed solution to be introduced to the liquid cyclone is V [m/s], and an inside diameter of a container of the cylindrical part 151 to which the aggregate mixed solution is introduced is D [m], $V \times V/D$ satisfies a following relational expression (1):

$$100 \leq V \times V/D \leq 5000 \quad \dots(1)$$

When $V \times V/D$ in the above expression is less than 100, there is a concern that the aggregate is not disintegrated sufficiently and collection efficiency of the magnetic

particles decreases. Although an upper limit is not particularly limited, about 5000 is preferred due to physical limits of the device structure. Under such conditions, the aggregate can be disintegrated sufficiently and can be subjected to the next process.

[0099] Note that when the aggregating agent is added to form a flock having magnetism as in the fourth embodiment, it is preferred to operate a larger shear force because the bonding force of the formed flock is relatively strong, and the aggregate is preferred to be treated under conditions satisfying a following relational expression (2):

$$1500 \leq V \times V/D \leq 5000 \quad \dots(2)$$

When $V \times V/D$ in the above expression is less than 1500, there is a concern that a generally formed flock cannot be disintegrated sufficiently in the water treatment to remove suspended substances by using the aggregating agent. By satisfying the above conditions, the flock can be disintegrated to an extent of allowing sufficient improvement in the collection efficiency.

[0100] Note that when the aggregating agent is added, strength of the flock to be formed varies depending on the amount of removal target substances contained in the raw water W1 and the amount of adding the aggregating agent, and the amount of adding the aggregating agent also affects the water quality of the treated water W2 to be obtained. Thus, while balancing these conditions, treatment conditions by which the flock is sufficiently disintegrated may be determined appropriately. At this time, the strength of the flock can be measured by, for example, a shear force generated by a bottomed cylinder and a rotor disposed in this bottomed cylinder as a known art, and the treatment conditions will be efficiently determined by referring to the above strengths.

[0101] While several embodiments of the present invention have been described above, these embodiments have been presented by way of example, and are not intended to limit the scope of the inventions. The novel embodiments described herein may be implemented in a variety of other forms, and various omissions, substitutions and changes thereof may be made without departing from the spirit of the inventions. Such embodiments and modifications are included in the scope and spirit of the invention, and also included in the inventions described in the accompanying claims and their equivalents.

Claims

- [Claim 1] A water treatment system removing removal target substances contained in raw water as water to be treated, comprising:
an aggregate forming mechanism configured to mix the raw water and magnetic particles to form an aggregate containing the removal target substances and the magnetic particles;
an aggregate separating mechanism configured to separate the aggregate from the raw water to obtain purified treated water;
a disintegrating mechanism configured to apply a centrifugal force to the aggregate separated from the raw water to disintegrate the aggregate;
a separating and collecting mechanism configured to separate the magnetic particles obtained by a disintegration of the aggregate by using a magnetic force to collect the magnetic particles; and
a reusing mechanism configured to circulate the magnetic particles collected by the separating and collecting mechanism to the aggregate forming mechanism for formation of the aggregate.
- [Claim 2] The water treatment system of claim 1, wherein the disintegrating mechanism is a liquid cyclone.
- [Claim 3] The water treatment system of claim 2, wherein the liquid cyclone is provided in a circulation line circulating from the aggregate separating mechanism or the separating and collecting mechanism as a starting point.
- [Claim 4] The water treatment system of any one of claims 1 to 3, wherein the aggregate forming mechanism has a filtering device,
the filtering device includes a filtration surface and a precoat layer formed by depositing the magnetic particles as a filter aid on the filtration surface, and is capable of forming the aggregate by supplying the raw water to the precoat layer.
- [Claim 5] The water treatment system of any one of claims 1 to 3, wherein the aggregate forming mechanism has a magnetic particle adding portion and an aggregating agent adding portion which are capable of forming a flock having magnetism by adding the magnetic particles and an aggregating agent to the raw water.
- [Claim 6] The water treatment system of any one of claims 1 to 5, wherein a flow rate of an aggregate mixed solution containing the aggregate to be supplied to the disintegrating mechanism is V [m/s], and an inside

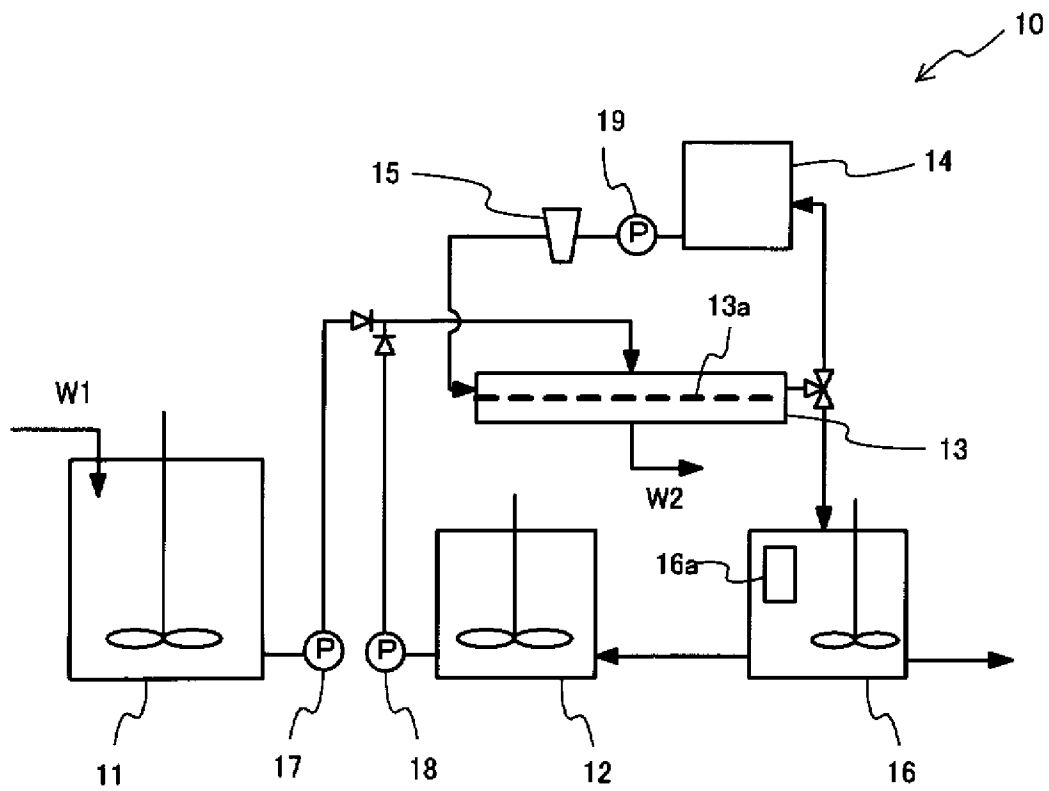
diameter of a container to which the aggregate mixed solution is supplied in the disintegrating mechanism is D[m], $V \times V/D$ satisfies a following relational expression (1):

$$100 \leq V \times V/D \leq 5000 \quad \dots(1)$$

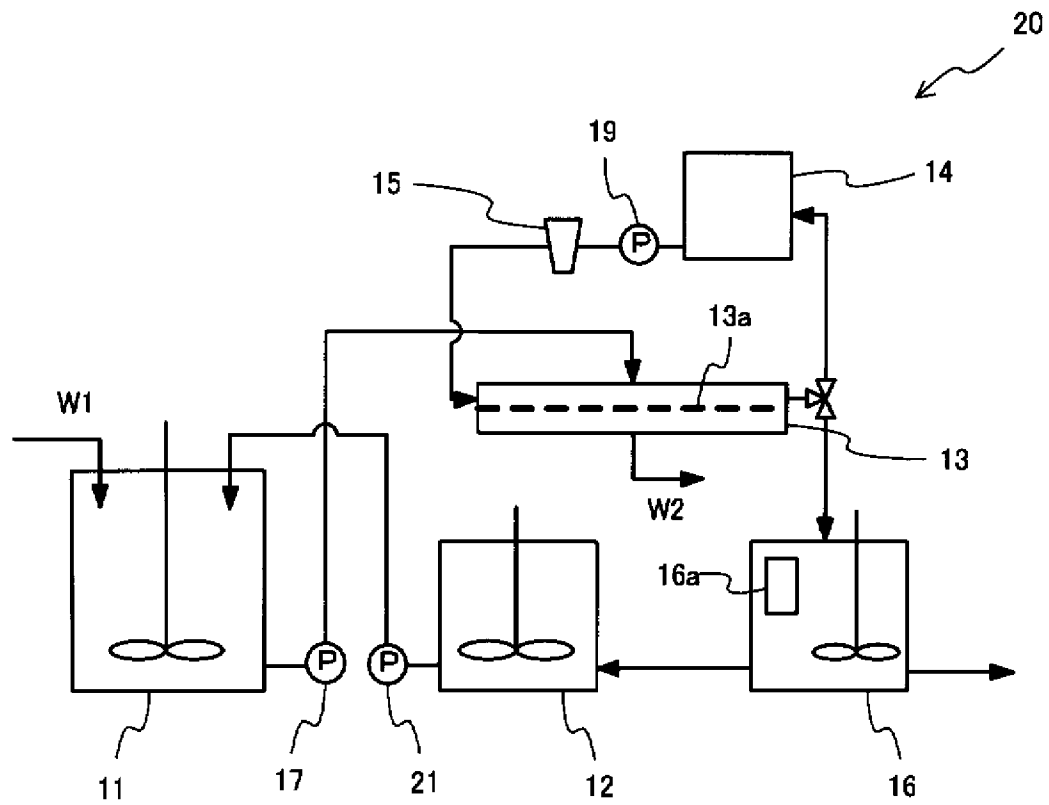
[Claim 7]

A water treatment method removing removal target substances contained in raw water to be treated, comprising:
 mixing the raw water and magnetic particles to form an aggregate containing the removal target substances and the magnetic particles;
 separating the aggregate from the raw water to obtain purified treated water;
 applying a centrifugal force to the aggregate separated from the raw water to disintegrate the aggregate;
 separating the magnetic particles obtained by a disintegration of the aggregate by using a magnetic force to collect the magnetic particles;
 and
 reusing the magnetic particles obtained by a disintegration of the aggregate for formation of the aggregate to mix the raw water.

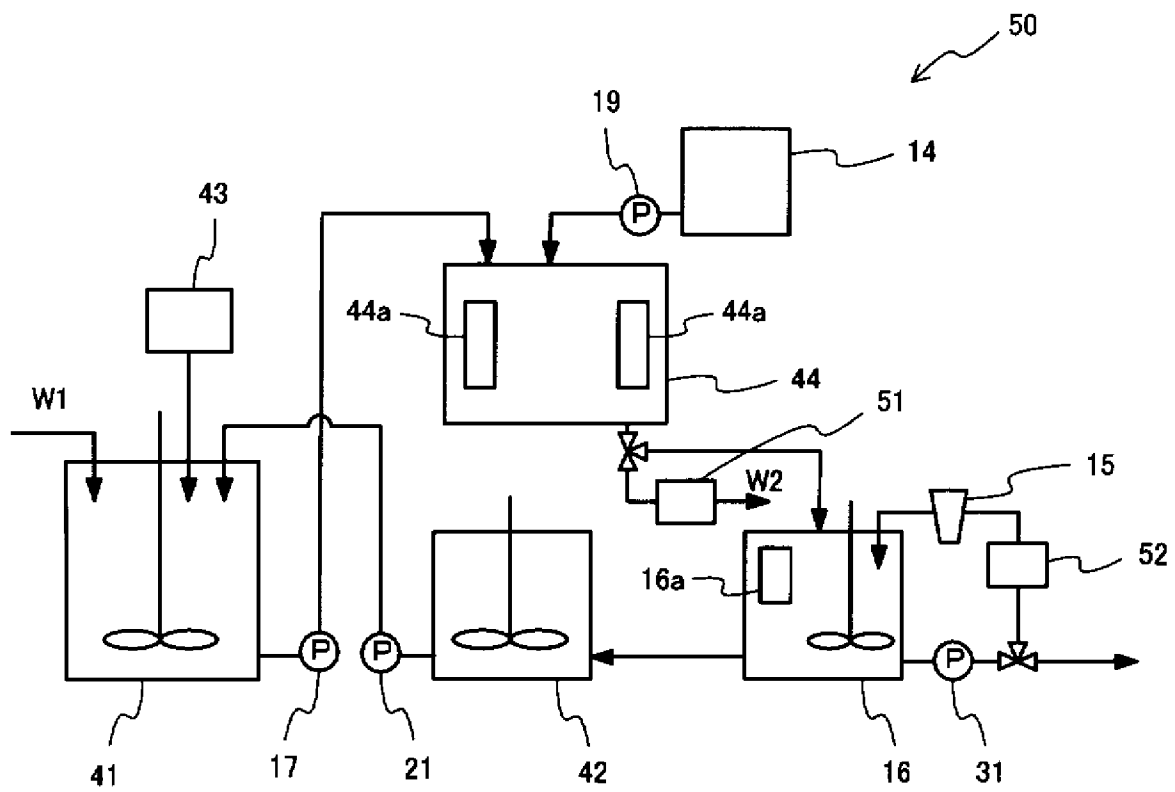
[Fig. 1]



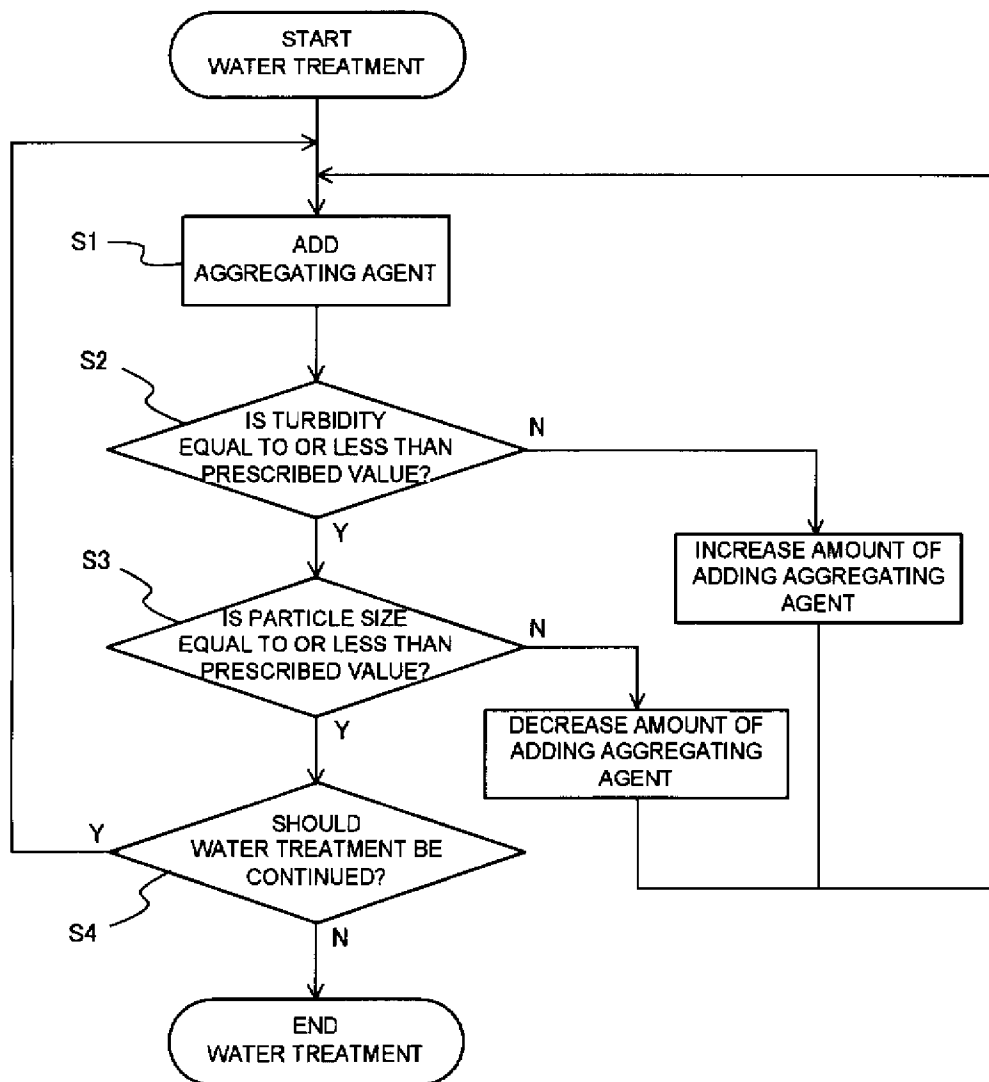
[Fig. 2]



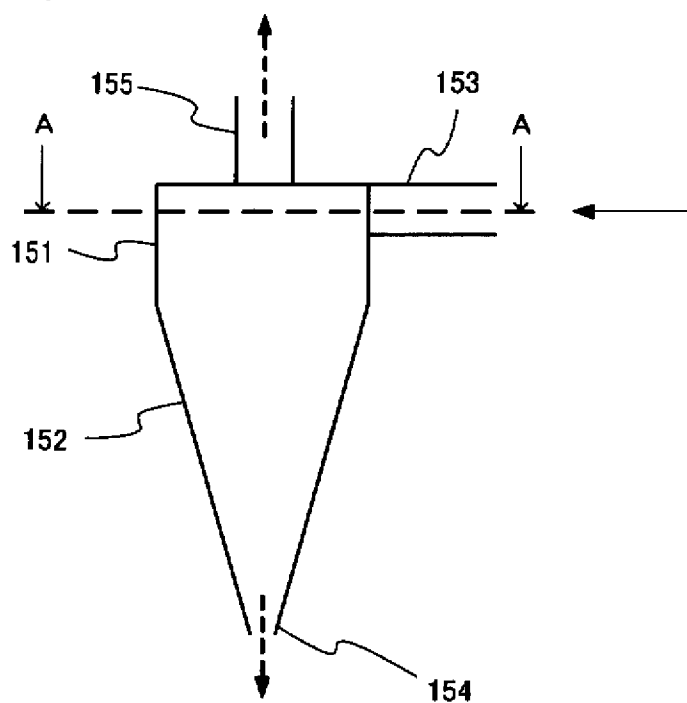
[Fig. 5]



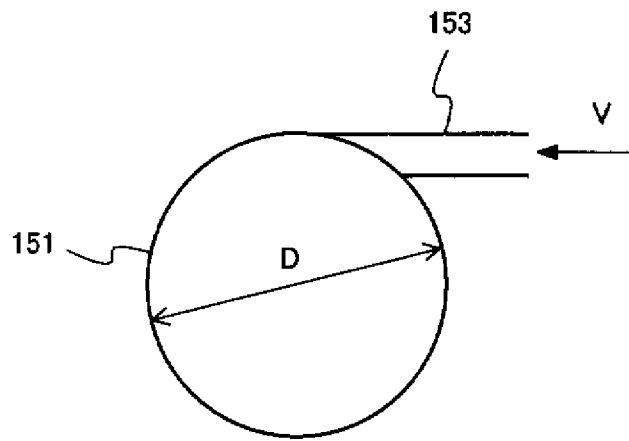
[Fig. 6]



[Fig. 7A]



[Fig. 7B]



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2015/001200

A. CLASSIFICATION OF SUBJECT MATTER

INV. C02F1/48 C02F1/38
ADD. C02F1/52 C02F1/56 C02F101/10 C02F101/20 C02F103/10
C02F103/16 C02F103/32 C02F103/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	paragraphs [0078] - [0119]; claims -----	6
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

5 May 2015

Date of mailing of the international search report

15/05/2015

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INTERNATIONAL SEARCH REPORT

International application No
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