Claims

1. A water treatment device for filtering raw water using a hollow fiber membrane module, the water treatment device comprising:

a storage unit configured by a storage device;

a measurement unit configured to cause a pressure sensor to repeat measurement of pressures on a primary side and a secondary side of the hollow fiber membrane module every minute time of one second or less in one or more of a water filling step, a backwashing step, a pressure relieving step, a bubbling step, and a draining step, and to store pressure logging data indicating the measured pressures on the primary side and the secondary side in the storage unit; and

an estimation unit configured to estimate

(1) abnormality of an internal state of the hollow fiber membrane module or of a peripheral device of the hollow fiber membrane module,

(2) a time required from a start to an end of the one or more steps,

(3) an effect of physical washing or chemical washing of the hollow fiber membrane module, or

(4) a future increase in an membrane differential pressure of the hollow fiber membrane module,

based on a temporal transition of a measurement result of at least one pressure of the primary side and the secondary side pressures, or

when the one or more steps are performed a plurality of times, based on a difference in the temporal transition between the plurality of times of the step.

2. The water treatment device according to claim 1, wherein

the water filling step is a step of filling an inside of the hollow fiber membrane module with raw water,

the one or more steps include the water filling step, and

the estimation unit is configured to estimate a time required for the water filling step based on a time from a start of the water filling step to reaching to an inflection point of a change in the pressure on the primary side.

3. The water treatment device according to claim 1, wherein

the water filling step is a step of filling an inside of the hollow fiber membrane module with raw water,

the one or more steps include the water filling step, and

the estimation unit is configured to estimate an amount of suspended components accumulated on a surface of a hollow fiber membrane based on a time from a start of the water filling step to reaching to an inflection point of a change in the pressure on the primary side.

4. The water treatment device according to claim 1, wherein

the water filling step is a step of filling an inside of the hollow fiber membrane module with raw water,

the one or more steps include the water filling step,

the measurement unit is configured to, when the water filling step is performed a plurality of times, repeat the measurement in each of the plurality of times of the water filling step, and

the estimation unit is configured to estimate a future increase in the membrane differential pressure based on a difference, between the plurality of times of the water filling step, in a time from a start of the water filling step to reaching to an inflection point of a change in the pressure on the primary side, and

the water treatment device further comprises a notification unit configured to notify a result of the estimation by the estimation unit.

5. The water treatment device according to claim 1, wherein

the draining step is a step of draining drain water containing peeled off suspended components,

the one or more steps include the draining step, and

the estimation unit is configured to estimate a time required for the draining step based on a time from a start of the draining step until the pressure on the primary side stabilizes.

6. The water treatment device according to claim 1, wherein

the draining step is a step of draining drain water containing peeled off suspended components,

the one or more steps include the draining step, and

the estimation unit is configured to estimate an amount of suspended components accumulated on a surface of a hollow fiber membrane based on a time from a start of the draining step until the pressure on the primary side stabilizes.

7. The water treatment device according to claim 1, wherein

the draining step is a step of draining drain water containing peeled off suspended components,

the one or more steps include the draining step,

the measurement unit is configured to, when the draining step is performed a plurality of times, repeat the measurement in each of the plurality of times of the draining step, and

the estimation unit is configured to estimate a future increase in the membrane differential pressure based on a difference, between the plurality of times of the draining step, in a time from a start of the draining step until the pressure on the primary side becomes constant, and

the water treatment device further comprises a notification unit configured to notify a result

of the estimation by the estimation unit.

8. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step, and

the estimation unit is configured to estimate a time required for the backwashing step based on a time from a start of the backwashing step until the at least one of the pressures becomes constant or until the at least one of the pressures reaches a maximum pressure.

9. The water treatment device according to claim 8, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step, and

the estimation unit is configured to estimate a length of a time of a chemical solution immersion step of the hollow fiber membrane module based on an estimated time of the backwashing step.

10. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step,

the measurement unit is configured to, when the backwashing step is performed a plurality of times, repeat the measurement in each of the plurality of times of the backwashing step, and

the estimation unit is configured to

(1) estimate a blockage degree of the hollow fiber membrane based on a time from a start of the backwashing step until the pressure on the primary side stabilizes at a predetermined end pressure indicating an end of the pushing out of the treated water on the secondary side, or

(2) estimate an effect of the physical washing or the chemical washing, or a future increase in the membrane differential pressure based on a difference, between the plurality of times of the backwashing step, in a time from the start of the backwashing step until the pressure on the primary side stabilizes at the end pressure.

11. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step,

the measurement unit is configured to, when the backwashing step is performed a plurality of times, repeat the measurement in each of the plurality of times of the backwashing step, and

the estimation unit is configured to

(1) estimate a magnitude of a pipeline resistance of a drain pipeline on the primary side based on a reaching point of the pressure on the primary side that has instantaneously increased immediately after a start of the backwashing step, or

(2) estimate an effect of the physical washing or the chemical washing, or a future increase in the membrane differential pressure based on a difference in the reaching point between the plurality of times of the backwashing step.

12. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step,

the measurement unit is configured to, when the backwashing step is performed a plurality of times, repeat the measurement in each of the plurality of times of the backwashing step, and

the estimation unit is configured to estimate an effect of the physical washing or the chemical washing, or a future increase in the membrane differential pressure based on a difference, between the plurality of times of the backwashing step, in a time from a start of the backwashing step until the pressure on the secondary side stabilizes at a pressure of the medium.

13. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step,

the measurement unit is configured to, when the backwashing step is performed a plurality of times, repeat the measurement in each of the plurality of times of the backwashing step, and

the estimation unit is configured to estimate an effect of the physical washing or the chemical washing, or a future increase in the membrane differential pressure based on a difference, between the plurality of times of the backwashing step, in a reaching point of the pressure on the secondary side that has instantaneously increased immediately after a start of the backwashing step.

14. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step,

the measurement unit is configured to, when the backwashing step is performed a plurality of times, repeat the measurement in each of the plurality of times of the backwashing step, and

the estimation unit is configured to

detect a reaching point of any one of the pressure on the primary side and the pressure on the secondary side that have instantaneously increased immediately after a start of the backwashing step with respect to the plurality of times of the backwashing step, and

estimate a degree of progress of clogging of the hollow fiber membrane, an effect of the physical washing or the chemical washing, or a future increase in the membrane differential pressure based on a difference, between the plurality of times of the backwashing step, in a difference between the pressure on the secondary side and the pressure on the primary side at a time point at which the any one of the pressures reaches the reaching point.

15. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step,

the measurement unit is configured to, when the backwashing step is performed a plurality of times, repeat the measurement in each of the plurality of times of the backwashing step, and

the estimation unit is configured to, with respect to the plurality of times of the backwashing step,

calculate an integral value of a difference between the pressure on the secondary side and the pressure on the primary side in any one of

(1) a time from a start of the backwashing step until the pressure on the primary side or the secondary side that has instantaneously increased immediately after the start of the backwashing step reaches a reaching point,

(2) a time from when the pressure on the primary side or the secondary side that has instantaneously increased immediately after the start of the backwashing step reaches the reaching point until the pressure stabilizes, and

(3) a time from a start time point of the backwashing step to a time point at which the pressure on the primary side or the secondary side stabilizes, and

estimate an effect of the physical washing or the chemical washing, or a future increase in the membrane differential pressure based on a difference in the integral value between the plurality of times of the backwashing step.

16. The water treatment device according to claim 1, wherein

the backwashing step is a step of pushing out treated water on the secondary side to the primary side by a pressurized medium to peel off suspended components accumulated on a surface

of a hollow fiber membrane in a filtration step,

the one or more steps include the backwashing step, and

the estimation unit is configured to, when the pressure on the secondary side has stabilized in the backwashing step, estimate whether or not the hollow fiber membrane leaks by comparing the stabilized pressure on the secondary side with a pressure of the medium.

17. The water treatment device according to claim 1, wherein

the bubbling step is a step of causing a gas to flow in when the inside of the hollow fiber membrane module is full of water, and shaking a hollow fiber membrane to peel off suspended components accumulated on a surface of the hollow fiber membrane,

the one or more steps include the bubbling step, and

the estimation unit is configured to estimate whether or not the peripheral device that allows the gas to flow into the hollow fiber membrane module has abnormality by comparing a predetermined pressure with a reaching point of the pressure on the primary side that has instantaneously increased immediately after a start of the bubbling step.

18. The water treatment device according to any one of claims 2, 5, 8, and 9, further comprising a setting change unit configured to change a set time of the one or more steps based on an estimated time obtained by the estimation unit,

wherein the setting change unit is configured to change set times of a plurality of steps among the water filling step, the pressure relieving step, the backwashing step, and the draining step based on an estimated time obtained by the estimation unit.

19. The water treatment device according to claim 1, further comprising:

a control unit configured to control execution of a filtration process of filtering raw water using the hollow fiber membrane module; and

a notification unit configured to notify a content of abnormality when the estimation unit estimates that the internal state of the hollow fiber membrane module or the peripheral device has the abnormality,

wherein the filtration process includes the one or more steps, and

the control unit is configured to

cause the estimation unit to estimate, at the end of each step after a start of the filtration process, whether or not the internal state of the hollow fiber membrane module or the peripheral device has abnormality based on a temporal transition of the least one of the pressures measured by the measurement unit at each step, and

(1) in a case where the notification unit notifies the content of the abnormality, end the filtration process being executed, or

(2) in a case when the estimation unit estimates that the internal state of the hollow fiber membrane module has abnormality at the end of the water filling step, the backwashing step, or the

draining step, enhance the physical washing or perform the chemical washing.

20. An estimation method in a water treatment device for filtering raw water using a hollow fiber membrane module, wherein

a computer of the water treatment device

repeats measurement of pressures on a primary side and a secondary side of the hollow fiber membrane module every minute time of one second or less in one or more of a water filling step, a backwashing step, a pressure relieving step, a bubbling step, and a draining step, and stores pressure logging data indicating the measured pressures on the primary side and the secondary side in a storage unit configured by a storage device included in the water treatment device and

estimates

(1) abnormality of an internal state of the hollow fiber membrane module or of a peripheral device of the hollow fiber membrane module,

(2) a time required from a start to an end of the one or more steps,

(3) an effect of physical washing or chemical washing of the hollow fiber membrane module, or

(4) a future increase in an membrane differential pressure of the hollow fiber membrane module,

based on a temporal transition of a measurement result of a pressure of at least one of the primary side and the secondary side, or

when the one or more steps are performed a plurality of times, based on a difference in the temporal transition between the plurality of times of the step.