

NANOFILTRATION MEMBRANE WATER PROCESS SYSTEM AND DEVICE

FIELD OF THE INVENTION

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The present invention relates to a low energy consumption water process system which uses nanofiltration membrane, and in particular, relates to a water process system which desalts excessive hardness and color degree in low-salt water, without adding other chemicals in drinking water in after treatment processes, and achieves or exceeds new edition "Sanitary standard for drinking water" in China. The present invention belongs to drinking water process area.

BACKGROUND ART

15 China is a water-resource indigent country. Per capita fresh water resource in China is about a quarter of the world's average level, and the water pollution is also serious. Nanofiltration and reverse osmosis membrane technology are required to remove the affection of heavy metal, organic pollutant, high salinity, high toxin and part of pathogenic microorganism in water. However, the equipment and operating cost of nanofiltration and reverse osmosis is high. To take the drinking water as an example, cost of water
20 processed by membrane technology is increased by 15%~30%, and it has several problems. First, the conventional high-pressure reverse osmosis membrane device needs large investment (about 10000 CNY/ ton water device); second, it has high working pressure (30~40kg/cm²) and high energy consumption (about 6kwh/ton), with complex energy recovery device and high water producing cost which is up to 6 CNY/ton, and thus
25 is hard for mass production. If a differentiated low pressure nanofiltration membrane system can be acted according to circumstances, the water producing energy consumption and cost are reduced greatly.

30 The specification of Chinese utility model patent CN2561780Y discloses a "deep sea water desalination machine" in which the desalination machine is totally disposed in sea water during usage, and deep sea pressure is used as energy for saving energy used in sea water desalination. However, the device is complex, the process is hard to perform, and it has no effective solution on surface water and underground water with low salinity.

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The largest application field of nanofiltration membrane is softening drinking water and removing organics in drinking water. Nanofiltration and reverse osmosis do not have

specific boundary, and the operation pressure range of the nanofiltration membrane is between ultra filtration and reverse osmosis. The membrane pore diameter is substantially somewhat larger than that of reverse osmosis, and allows small molecule organics and monovalent ions to pass through. The nanofiltration has low operation pressure, high
5 membrane flux and low device operation cost, and it can use the surface water or underground water with slight pollution as the raw water of the nanofiltration membrane water process.

SUMMARY

10 To sum up, the technical problem that the present invention aims to solve is to provide a low energy consumption nanofiltration membrane water process system which is adapted to the areas where water is supplied by surface water, underground water, and /or mountain area water according to designed water producing quantity and the selected
15 topographic condition on the basis of reverse osmosis fresh water producing devices, and a device used for replacing activated carbon and/or fiber cloth. A device for assembling and taking out nanofiltration membrane elements from the well is applied for another patent separately.

20 To solve the technical problem above, the present invention chooses corresponding water process project according to water resource condition, water quality ingredient and inorganic components in water, water temperature, water output and water quality index of the specified area. When the raw water has low salinity and does not require high
25 desalination rate, nanofiltration is an effective technical solution to replace the reverse osmosis, and it may also replace the flocculation, sedimentation, sand filtering and chlorine disinfection in the conventional drinking water processes. As a result, the water process system according to an aspect of the present invention using nanofiltration as the core is: water taking well → desilting area + porous brick biological filter + oxygenators
30 supplying oxygen continuously → non-fine concrete filtering pool → activated carbon filtering pool → coarse filter cloth + fine filter cloth + catchment area → nanofiltration → pure and clean water + concentrated water. The water taking well is disposed at periphery of the filtering pool or dug at the bottom of the filtering pool, and the wellhead at the bottom of the filtering pool may be disposed at the construction wall of the filtering pool reinforced concrete. During civil engineering of filtering pool, the water taking well can be
35 used as dewatering well with the depth of 10~20m; the well water pumped by the submerged pump is pumped to the desilting pool via the collecting pipe, and oxygen-enriched air from pressure swing adsorption oxygenator flows into the bottom of the

porous brick biological filtering pool to form biological activated filtering pool, or the oxygenator supplies oxygen at the bottom of the porous brick biological filtering pool to reproduce biocoenosis in the pool; the microorganism eats the organics in water, which is similar as self-purification of natural world water. Water is filtered coarsely in the non-fine concrete filtering pool, and is filtered finely in the activated carbon filtering pool. The pre-processed water passing through the filter cloth component pool is led into the steel pipe equipment well. The nanofiltration membrane component is disposed at the bottom of the well which has a depth of 40~70m. The static pressure energy formed by water level difference is used as working pressure of the nanofiltration membrane, which replaces expensive and high energy consuming high pressure pump. The clean water flowing through the nanofiltration membrane is pumped out by the water producing deep well submerged pump, which overcome hydraulic head and on-way resistance of pipe to pump the clean water out of the well, which is high-quality drinking water.

The porous brick biological filtering pool of the nanofiltration membrane water process system can be built at lower portion along river bank, where the capacity is large enough. The amount of the well at the periphery of the filtering pool depends on water output. The pore area of the porous brick is larger than the surface area of the porous brick, and three-pore bricking area, eight-pore bricking area, twenty-pore bricking area with increasing water absorption and pore ratio are arranged along the water flow direction of the filtering pool. The porous brick is commercial shale brick, which are stacked intersecting with each other and fills in the blocking wall of the reinforced concrete. Transition area between bricking areas are used for buffering. Water flowing through the porous brick biological filtering pool has the speed of 5m/s~10m/s.

The non-fine concrete is a preamble, multi-pored, light concrete mixed by coarse aggregate, cement and water. The section of the non-fine concrete filtering pool in the present invention is substantially rectangle shaped, and a plurality of pea gravel no-fines concrete filtering walls are disposed evenly inside the rectangle shaped non-fine concrete filtering pool, namely 3~8mm pea gravel and cement are mixed in a proportion of 6:1. A floor ceramic tile is paved at the construction wall to prevent water, and the reinforced concrete is used for sealing. The filtering wall is reinforced in different stages with reinforced concrete construction pillar; a clean water passage is at the middle; the height and width of the filtering wall allows person to enter for desilting; and the air pipe is used as safety guarantee for maintenance.

Clean water flowing out of the non-fine concrete filtering pool flows into the activated carbon filtering pool formed by a plurality of activated carbon filter baskets. The filter material layer has the thickness of 0.5~1m and packing porosity is 30~45%. The activated carbon absorbs residual insoluble impurities and most soluble impurities. The activated carbon basket is manufactured with aluminum alloy section frame covered with stainless steel half-tone, and wheels are assembled for sliding along the filtering pool slot up and down. The activated carbon filter includes a top cover to pull the basket out and replace the granular activated carbon.

The nanofiltration membrane water process system device includes a filter cloth component which is also manufactured with aluminum alloy section frame covered with stainless steel half-tone. The filter cloth is fixed by clamp plates. Each filter cloth component is attached to the construction pillar of the reinforced concrete to form blocking wall. A coarse filter cloth covers at the water inlet direction, the pore of which is 80~120um, and a fine filter cloth covers the water outlet direction, the pore of which is 8~12um. The height and width of the blocking wall allow person to enter for taking filter cloth to wash or change.

The pre-processed water flows into the nanofiltration membrane component in the steel pipe equipment well through the water collecting pool via pump or water level difference. In the present invention, the nanofiltration membrane component is disposed at the bottom of the well. Water level difference is used as driving force of nanofiltration membrane, and the nanofiltration membrane allows a maximum operating pressure 4.14Mpa. The clean water recovery rate is 50%, static pressure exerted on the membrane element in water is proportional to the depth that the membrane element is disposed into the water. When the water producing deep well submerged pump at the water outlet side works, the static pressure of the water outlet side of the nanofiltration membrane is reduced gradually. As the static pressure at the water inlet side is constant, static pressure difference between two sides of the membrane is up, and the water inlet is up therewith until it reaches the balance with the water pumping quantity. Pure and clean water is filtered by the membrane and pumped out of the well in the water storage pool. The water producing deep well submerged pump is used to overcome the on-way resistance, and recovered water or undrinkable concentrated water is directly discharged in the well, and then flows out from water level difference or pumped out by pumps.

In a nanofiltration membrane water process control system, the water producing deep well submerged pump is equipped with a frequency converter, the software of frequency

converter in the water producing deep well submerged pump is embedded with program of periodic motor frequency conversion. Clean water pumped by the water producing deep well submerged pump is pumped into the water storage pool. The water storage pool is disposed with a upper water level pressure sensor and a lower water level pressure sensor. When water level reaches the upper level, the pressure sensor indicates the motor of the water producing pump to stop operating, and when the water level reaches the lower level, the pressure sensor indicates the pump to pump water to achieve normal water supply. In addition, when the pressure difference between two sides of the nanofiltration membrane is larger than a specific value, a clean water reverse at water inlet side of membrane periodically is performed automatically, which removes the membrane pore blocking, flux reducing and resisting force increment due to concentration polarization at condense water side, and prolongs the performance and lifespan of the membrane.

The beneficial effect of the present invention lies in: it is easy and practical than the conventional tap water supply system; since a porous brick filtering pool and filter cloth component are used, the device cost is reduced greatly; water level difference is used to form potential energy and is transferred to driving force of the nanofiltration membrane; the upper portion of the filtering pool is close and does not occupy surface ground area; chemicals are not added to the pure water during membrane process; and it can be used in waste water with solvents.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram showing the nanofiltration membrane water process system according to an embodiment of the present invention.

FIG. 2 is a planar diagram showing the nanofiltration membrane water process device according to the embodiment of the present invention (the upper side of the filtering pool is not closed).

FIG. 3 is a sectional diagram showing the porous brick biological filtering pool taken along the line A-A in FIG. 2.

FIG. 4 is a sectional diagram showing the non-fine concrete filtering pool taken along the line B-B in FIG. 2.

FIG. 5 is a sectional diagram showing the activated carbon filtering pool taken along the line C-C in FIG. 2.

FIG. 6 is a sectional diagram showing the filter cloth component pool taken along the line D-D in FIG. 2.

Reference numerals in the figures:

1—water taking well; 2—water taking submerged pump; 3—desilting area; 4—porous brick biological filter, 4a—three-pore bricking area, 4b—eight-pore bricking area, 4c—twenty-pore bricking area, 4d—water preamble brick; 5—oxygenator; 6—no-fines concrete filter, 6a—pea gravel no-fines concrete wall, 6b—clean water passage, 6c—floor ceramic tile, 6d—air outlet pipe, 6e—pressure balancing pipe; 7—activated carbon filter, 7a—top cover, 7b—granular activated carbon, 7c—activated carbon basket; 8—filter cloth components pool, 8a—precast concrete cover, 8b—coarse filter cloth, 8c—fine filter cloth; 9—catchment area; 10—raw water centrifugal pump; 11—steel pipe equipment well; 12—water inlet pipe; 13—concentrated water outlet pipe; 14—purified water producing pipe; 15—nanofiltration membrane component; 16—water producing deep well submerged pump; 17—flow-limiting valve; 18—water storage pool; 19—frequency converter; 20—pressure sensor; 21—reinforced concrete; 22—collecting pipe; 23—transition area.

DETAILED DESCRIPTION OF THE INVENTION

Detailed embodiments of the present invention will be described hereinbelow referring to the drawings.

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First, a field research shows that it is preferable to build the water process system along a natural river bank. Then, a 15m deep well is dug and the water output is measured to be 25 m³/h. The water quality is measured that the SDI pollution index is 0.8, TDS (total dissolved solids) is 275mg/L, the NTU turbidity is 10.8, and the total hardness (measured by CaCO₃) is 202 mg/L. Other component contents are measured too. The project is to provide high quality drinking water and landscape water for villa district, it is determined to dig 12 wells with water producing quantity 10000m³/day. Natural water level difference between water source and the water process device to be built is used as far as possible. Water treatment processes are selected according to inorganic salt, heavy metal, organics and water pollutant condition, and the water recovery rate is set as a relative low value 50%.

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FIG. 1 is a schematic diagram showing that in an embodiment underground water is taken as raw water to produce drinking water by the processes of filtering and depositing, filling biological adsorption, filtering by micro-filtering cloth and nanofiltration. FIG. 2 is a planar diagram showing the nanofiltration membrane water process device, in which the upper side of the filtering pool is not closed. Referring to FIG. 1 and FIG. 2, the water taking submerged pump 2 has a steel filter screen itself, and pumps water from a plurality of water taking wells 1. The pumped water passes through collecting pipes 22 and flows to the desilting area 3. Water flows through three-pore bricking area 4a, eight-pore bricking area 4b and twenty-pore bricking area 4c in succession, and turns around to flow through two transition areas 23 in the area shown in FIG. 2, and the minimum open area is 12m². Oxygen pipe of the pressure swing adsorption oxygenator 5 is disposed at the bottom of the transition area 23, and the dissolved oxygen efficiency is higher than compressed air. The activated carbon filtering pool 7 has four water slots, each of which includes a water inlet-outlet to disposed two slidable activated carbon basket device. The hydraulic retention time of the activated carbon filtering pool 7 is 12~20s. The filtering area of the filter cloth component pool 8 is 120m², and the water flow direction in the water inlet-outlet passage and the water flow direction of water flowing into the filter cloth component is shown in FIGs. Water collecting areas 9 at two ends of the filter cloth component pool 8 is covered with precast concrete covers 8a. The nanofiltration membrane is also called extra low pressure reverse osmosis membrane, to brackish water in which contains 3g/L NaCl and does not require high desalination rate. The osmotic pressure is $7.038 \text{ mH}_2\text{O} \cdot \text{L/g} \times 3\text{g/L} = 21.11 \text{ mH}_2\text{O} = 2.1 \text{ kg/cm}^2$. Preferably, a VONTRON VNF1-8040 nanofiltration membrane with reliable performance and low cost is used. To satisfy the working pressure of osmosis membrane 4~5kg/cm², namely 4~5Mpa, the nanofiltration membrane component 15 is disposed in the steel pipe equipment well 11 in the depth of 40~70m. A single nanofiltration membrane element has water producing quantity of 22.2 m³/day, and six nanofiltration membrane elements connected in series are filled in a stainless steel membrane casing. 26 stainless steel membrane casings are connected in parallel, and as a result, there are totally 156 nanofiltration membrane elements. The concentrated water outlet pipe 13 of the nanofiltration membrane component 15 directly discharges concentrated water in the well, and then discharges out of the well by water pressure. The clean water producing pipe 14 pumps clean water to the water storage pool 18 by the water producing deep well submerged pump 16, and the nanofiltration membrane component 15 and related pipes are equipped with special lifting device for changing membrane elements and maintenance. The lifting device is applied for Chinese utility model patent in other application. The control system of the water producing deep

well submerged pump 16 includes a frequency converter disposed outside the well and interlocking with an upper water level pressure sensor 20 and a lower water level pressure sensor 20. The frequency converter matches with a flow-limiting valve 17 to realize water flow quality and power self-control, as well as fresh water reverse at the water inlet side of membrane periodically, thereby prolonging the lifespan of the membrane.

FIG. 3 to FIG. 6 are sectional diagrams showing four connected filtering pools in FIG. 2. The construction relations which need to be supplemented are: as shown in FIG. 3, three-pore bricking area 4a, twenty-pore bricking area 4c are stacked intersecting with each other in brick-pore direction; cement mortar is not used for preventing pollution; water preamble brick 4d covers the three-pore bricking area 4a and the twenty-pore bricking area 4c at the top; and all the bricks are commercial bricks sold in the market. FIG. 4 shows clean water passage 6b, air pipe 6d and floor ceramic tile 6c. The floor ceramic tile 6c is 800mmX800mm, and the pressure balancing pipe 6e preserves the concrete foundation settlement; cast-in-place reinforced concrete 21 is used as filling wall of frame structure, and the pea gravel no-fines concrete wall 6a is also reinforced with construction pillar of reinforced concrete 21. The surface of pea gravel is covered with a thin layer of cement paste, which adheres with each other to form cellular structure with evenly distributed pores. Pea gravel is coarse aggregate, and as a result, it is also named no sand macroporous concrete. As shown in FIG. 5, the granular activated carbon 7b is filled in the activated carbon basket 7c, and the top cover 7a is formed with eight parts. FIG. 6 shows that the coarse filter cloth 8a and fine filter cloth 8b are back-to-back disposed, and a stainless plate supported in the middle includes protrusions and holes. The filter cloth should satisfy hygiene standard of FDA requirement, so polyester material with better water leakage and abrasion resistance may be used.

The foregoing is only one embodiment of the present invention. The present invention is not limited to the above embodiment, and other design combination may also be used. All changes or modifications that can be derived directly or obtained based on the disclosure of the present invention by the skilled in the art should also fall within the protection scope of the present invention.

CLAIMS

1. A nanofiltration membrane water process system, comprising water taking wells (1), a porous brick biology filtering pool, a non-fine concrete, activated carbon, a filter cloth filtering pool and a steel pipe equipment well which are connected in series, wherein the water taking wells (1) are several wells dug around the filtering pool, a wellhead at the bottom of the filtering pool is disposed at a wall body of a reinforced concrete (21), the well has a depth of 10~20m; raw water is pumped by a water taking submerged pump (2) and is collected to a desilting area (3) by a collecting pipe (22), a oxygenator (5) supplies oxygen continuously at the bottom of a porous brick biological filter (4); pre-processed water flowing through a filter cloth component pool (8) is led to a nanofiltration membrane component (15) at the bottom of a steel pipe equipment well (11), and the well has a depth of 40~70m.
2. The nanofiltration membrane water process system according to claim 1, water in the desilting area (3) directly flowing into the porous brick biological filter (4) directly, wherein the pore direction of the porous brick biological filter pool (4) goes along the water flow direction of the filtering pool, bricks fill in a three-pore bricking area (4a), an eight-pore bricking area (4b) and a twenty-pore bricking area (4c), the porous brick are stacked intersecting with each other and fills in the construction wall of a reinforced concrete (21), a transition area (23) is disposed between the bricking areas for buffering, and water flowing through the porous brick biological filter (4) has the speed of 5m/s~10m/s.
3. The nanofiltration membrane water process system according to claim 1, water flowing out of the porous brick biological filter (4) flows into a non-fine concrete filtering pool (6), wherein the section of the non-fine concrete filtering pool (6) is rectangle shaped, a plurality of pea gravel no-fines concrete filtering walls (6a) are evenly disposed inside the rectangle shaped non-fine concrete filtering pool (6), namely 3~5mm pea gravel and cement are mixed in a proportion of 6:1, a floor ceramic tile (6c) is paved at the construction wall to prevent water, and the reinforced concrete (21) is used for sealing, the filtering wall is reinforced in different stages with construction pillar of reinforced concrete (21), a clean water passage (6b) is at the middle, and the height and width of the filtering wall allows person to enter for desilting.
4. The nanofiltration membrane water process system according to claim 1, water flowing out of a non-fine concrete filtering pool (6) flows into an activated carbon filter (7) via a clean water passage (6b), wherein a top cover (7a) of the activated carbon filter pool (7) is

capable of opening to take a activated carbon basket (7c) and granular activated carbon (7b) out, and the packing porosity is 30~45%, and the activated carbon basket (7c) is manufactured with aluminum alloy section frame covered with stainless steel halftone.

5 5. The nanofiltration membrane water process system according to claim 1, water flowing out of an activated carbon filter (7) flows into the filter cloth component pool (8), wherein a filter cloth component of the filter cloth component pool (8) is also manufactured with aluminum alloy section frame covered with stainless steel halftone, each filter cloth component is attached to the construction pillar of reinforced concrete (21) to form
10 blocking wall, a coarse filter cloth (8a) covers at the water inlet direction, the pore of which is 80~120um, a fine filter cloth (8b) covers the water outlet direction, the pore of which is 8~12um, and the height and width of the blocking wall allows person to enter for taking filter cloth out to wash or change.

15 6. The nanofiltration membrane water process system according to claim 1, water flowing out of the water outlet passage of the filter cloth component pool (8) flows into the nanofiltration membrane component (15) in the steel pipe equipment well (11) via a raw water centrifugal pump (10) and via a water collecting pool (9), wherein the nanofiltration membrane component (15) is disposed in the bottom of the steel pipe equipment well (11),
20 it uses deep water pressure as the driving force of the nanofiltration membrane, the clean water recovery rate is 50%, the static pressure exerted on the membrane element during water inlet is equal to a water pressure in a vertical height of the inlet and outlet pipe, a water producing deep well submerged pump (16) at the water outlet side pumps the purified water flowing through the nanofiltration membrane to a water storage pool (18)
25 outside the well, and the recycled water or undrinkable concentrated water is directly discharged inside the well, the mixed water is discharged via water pressure.

7. A water producing deep well submerged pump (16) used in the nanofiltration membrane water process system according to claim 6, comprising a frequency converter
30 (19) being disposed outside the well, wherein the frequency converter (19) interlock with an upper water level pressure sensor (20) and lower water level pressure sensor (20) of the water storage pool (18) at water outlet side of the nanofiltration membrane component (15), thereby achieving self control of water flow rate and power and balance of pressure difference at two sides.

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8. The water producing deep well submerged pump (16) according to claim 7, wherein software of frequency converter (19) in the water producing deep well submerged pump

(16) is embedded with a program of periodic motor frequency conversion, to achieve clean water reverse at water inlet side of membrane periodically and remove the membrane pore blocking, flux reducing and resisting force increment due to concentration polarization at concentrated water side.

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