

SUSPENSION CLARIFICATION AND FILTRATION DEVICE

FIELD OF THE INVENTION

- 5 The present invention relates to a suspension clarification and filtration device, which belongs to a field of liquid filtration and purification.

BACKGROUND ART

- 10 Liquid materials generally contain various rough, fine and particulate impurities which are required to be purified by precipitation separation and concentration filtration. For instance, the usually used water treatment methods are as follows.

- 15 Dalton clarifier: having a simple structure, a large area occupied, a low settlement and clarification efficiency, and a poor effect;

- Sand filter: having a simple structure and a high efficiency, but also having a low filtration accuracy, a requirement of periodical backwashing, and an incapability of continuous operation;

- 20 Hydraulic cyclone: having a simple structure and a high efficiency, but only having a capability of separating relatively rough particles;

- 25 Inclined-tube settler: having a lightly complex structure, a high efficiency, a small area occupied and a continuous operation, but having an insufficient settlement and clarification accuracy;

- 30 Tubular filter: being a terminal-filtration, adopting filter tubes made of high molecular polymers, having a complex structure, an expensive price and a high filtration accuracy, and also having an increased thickness for a filter cake and reduced filtration flux and efficiency as the filtration progresses, as well as a requirement of non-periodical backwashing and acidwashing, and hence influencing the operation;

- 35 Ceramic membrane filter: being a membrane filter newly developed in the last ten years, belonging to cross-flow filtration, having a filter membrane formed by sintering zirconium oxide, with a membrane thickness of only 2-3 μ m and a micropore size of only 0.05 μ m,

having a base body formed by sintering $\alpha\text{-Al}_2\text{O}_3$ at a high temperature, also having a high mechanical strength, a wear resistance and a high separation accuracy, a working pressure of up to $3\text{-}6\text{kg/cm}^2$, a high flux, an infrequent backwashing, a capability of long-term operation; having a price of 3-5 times of those of the above filtering apparatuses, a low one-time filtration rate (10-20%), a high recycle liquid flow rate, a high power consumption, and a wide application currently in the chemical industry, pharmaceutical industry, food industry, wine-making industry, water treatment industry, etc.

Commonly used industrial filtration processes generally adopt simple combinations of one or two foregoing filtration means such that the energy consumption and recycle of the system are not optimized; the number of material pumps used is large; and the energy consumption is high.

SUMMARY

By comprehensive comparison of the advantages and disadvantages of various foregoing clarification and filtration means, the technical problem to be solved by the present invention is to provide a suspension clarification and filtration device, which is formed by reasonable combination of several filtration devices and organic combination of respective advantages, and has advantages of a wide application range, a high filterability, a high filtration accuracy, a capability of utilizing the static pressure in the system, a convenient operation, a low energy consumption and a high investment price-performance ratio.

In order to solve the above technical problems, the device according to an aspect of the present invention comprises a hydraulic cyclone, an inclined-tube settler and a ceramic membrane filter. A suspension enters a liquid inlet pipe by a feed pump; a feed liquid enters the hydraulic cyclone along a tangential direction; after small particulates are removed, a separated crude supernatant enters the inclined-tube settler; relatively rough particulates are separated by the hydraulic cyclone, fall into a funnel area on a lower portion of the hydraulic cyclone, and are discharged by a reject valve timely; the separated crude supernatant on the upper portion of the hydraulic cyclone enters a lower portion of the inclined-tube settler via a feed pipe; the liquid flows up and runs through inclined tubes and a supernatant pipe; settled sludge is discharged by a reject valve; and a clarified supernatant enters the ceramic membrane filter via a supernatant pipe.

A liquid distribution area is disposed on the lower portion of the inclined-tube settler, a sludge area is disposed on a cone, a supernatant area is disposed on the top, and an inclined-tube settlement area is disposed in the middle. The inclined tube has a length of 1m, an inclination angle of 60°, and a height of approximately 0.866m; an interval space
 5 between adjacent inclined tubes is b (determined by the user); and the distance of the inclined tube in the geocentric gravity direction is $L = b/\cos 60^\circ = 2b$. In accordance with the stokes law, the settling velocity of particles is $W_s = d^2(r_s - r)/18\mu$ (m/s). In the formula, d refers to the diameter (m) of particles; r_s refers to the specific weight of particles (kg/m^3); r refers to the specific weight of supernatant (kg/m^3), and μ refers to the viscosity of
 10 supernatant (cps/9810).

In engineering practice, empirical data are generally adopted as the design basis, namely the channel flux of the inclined tubes takes a value of $9\text{--}11 \text{ m}^3/\text{m}^2 \cdot \text{H}$, thus the rising velocity of supernatant is approximately $W = 2.5\text{--}3 \text{ mm/s}$. The inclined tubes have a tube
 15 diameter of 25-50mm, a length of 1-1.2m, and an inclination angle of 60°. Subsequently, the required size or volume of the inclined tubes is calculated according to the processed feed liquid volume v . If the rising velocity of supernatant is 2.5mm/s, the maximum diameter of the settled particles is $d = (2.5 \times 10^{-3} \times 18\mu / \gamma_s - \gamma)^{0.5}$.

The device belongs to one-stage two-segment circulating process flow. The supernatant from the inclined-tube settler enters the ceramic membrane filter; a concentrated solution of the ceramic membrane filter accounts for approximately 80-90% of the feed liquid volume, returns back to the inclined-tube settler by a recycle pump via recycle liquid pipe, is mixed with a feed liquid from the hydraulic cyclone, and enters, together with the feed
 25 liquid from the hydraulic cyclone, the inclined-tube settler for settlement and clarification; a purified solution of the ceramic membrane filter flows into a purified solution tank via a purified solution pipe; and an exhaust valve is disposed on the supernatant pipe. In the conventional process, the power consumption of the device is higher than that of a terminal-filtration tubular filter. However, the device encloses the whole system, such that
 30 the pressure of the system can be fully utilized, and hence the energy consumption is lower than that of the traditional open process flow.

An inner wall of a ceramic membrane filter tube is a very thin zirconium oxide filter layer, and an outer wall of the ceramic membrane filter tube is an aluminum oxide frame layer
 35 with a high strength; and a pressure difference between the inner wall and the outer wall of the membrane tube is 1 kg/cm^2 . A stock solution entering from an upper opening is

infiltrated into micropores of the ceramic membrane and flows outside of the tube by means of the pressure difference, and hence a purified supernatant is obtained. The flux rate of the membrane wall of the membrane tube is approximately 10-20% of the feed liquid volume; a liquid flowing out from a lower opening of the ceramic membrane filter is referred to as a concentrated solution as the particulate concentration is raised; and a relatively high flow velocity of more than 2.5m/s is maintained in the membrane tube, so as to flush away particulates enriched on the membrane and prevent the membrane flux from being reduced. A pressure of approximately 2kg/cm² is applied to a liquid outlet of the closed inclined-tube settler; a pressure difference between both sides of the ceramic membrane wall is approximately 1kg/cm²; the purified solution flowing out of the filter membrane still has a pressure of 1kg/cm²; and the purified solution is pressed into a purified solution tank which is at about 10m above the ground by the static pressure. A head of a recycle liquid pressure pump is only used in a filtered solution for overcoming the on-way resistance of channels and pipelines of the ceramic membrane tube, so that the static pressure in the system can be utilized, and hence the energy consumption can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

Further description will be given below to the present invention with reference to the accompanying drawing:

FIG. 1 is a schematic diagram of a suspension clarification and filtration device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A process flow of an in-series combination of a hydraulic cyclone, an inclined-tube settler and a ceramic membrane filter is selected. The main points are as shown in FIG. 1: the hydraulic cyclone 4 settles large particulates at first, and the inclined-tube settler 7 settles medium and fine particulates through inclined tubes 8. Moreover, a purified solution flowing out of the ceramic membrane filter 12 is always kept in an extremely high filtration flux, as the particulates are not easily deposited on the wall of the ceramic membrane under a high liquid flow rate. Therefore, the backwashing frequency of the ceramic membrane, the power consumption and the overall investment of filtration equipment can be greatly reduced.

In a specific implementation, first, a solid phase content and a liquid phase content of a stock solution to be clarified and filtrated are analyzed, for instance, the specific weight of the feed liquid, the content of solid particles (mg/l) and the roughly composition ratio of particle sizes, and the hydraulic cyclone 4 and pipeline valves with appropriate manufacturers and models are selected according to the parameters such as the flow rate, the solid-liquid ratio and the outlet liquid ratio, etc.; then, the area, material and structure of the inclined tubes 8 of the inclined-tube settler 7 are designed according to general technical requirements of the inclined-tube settler 7; finally, the ceramic membrane filter 12 composed of a membrane housing and a membrane member is selected. Examples are as follows.

Suspension: crude brine (containing approximately 300g/l NaCl) is added with auxiliary materials (soda ash, barium chloride, etc.) at a speed of approximately 50m³/h and must be further clarified and filtered to remove various kinds of dirt and sand. The solid content accounts for approximately 1.5% of the weight. The specific gravity of the crude brine is approximately 1.20; the working time is approximately 12 hours per day, that is, the working flow rate is 100m³/h.

The handling capacity: $v = 100\text{m}^3/\text{h}$.

Selection of the hydraulic cyclone 4: XLCS-100B hydraulic cyclone produced by a factory in Shandong, with the parameters below: flow rate $V = 50\text{--}60\text{m}^3/\text{h}$ per hydraulic cyclone; $P_{\text{in}} = 3\text{kg}/\text{cm}^2$; pressure drop $\Delta P = 0.28\text{kg}/\text{cm}^2$; $P_{\text{out}} = 2.7\text{kg}/\text{cm}^2$.

Selection of the inclined-tube settler 7: the clarification capacity of inclined tubes is $10\text{m}^3/\text{m}^2\cdot\text{h}$; the area of the inclined tubes is $F_{\text{projection}} = 100/10 = 10\text{m}^2$ and $F_{\text{actual}} = F_{\text{projection}}/0.866 = 11.54\text{m}^2$, and it is 13m^2 when the thickness occupied by the tube wall is removed; the dimension of the inclined tubes is $4\text{m}\times 3.25\text{m}\times 1.2\text{m}$ (L×W×H); the inclined tube is in a shape of a hexagonal honeycomb; the pipe diameter is 40mm; a height of a water inlet area on a lower portion is 1m; a height of a cone sludge area is 1.5m; a height of the inclined tubes in the middle is $1.2\times 0.866 = 1.04\text{m}$; a height of a top supernatant area is 1.2m; and the total height is 4.74m. The flow rate of the supernatant in the inclined tubes is $w = v/f = 100/3600\times 10 = 2.78\times 10^{-3}\text{m}/\text{s} = 2.78\text{mm}/\text{s}$, and a flow rate of a supernatant area is $W = 100/3600\times 13 = 2.14\times 10^{-3}\text{m}/\text{s} = 2.14\text{mm}/\text{s}$. A shell of the inclined-tube settler 7 must bear an internal pressure of $3.2\text{kg}/\text{cm}^2$; the inclined-tube settler 7 is

manufactured into an enclosed container; and a valve 13 is used for exhaust or intake in the case of starting and stopping and used for discharging non-condensable gas in the system in the case of normal operation.

- 5 Selection of the ceramic membrane filter 12: the flux of the ceramic membrane is approximately $0.5\text{m}^3/\text{h}\cdot\text{m}^2$; the filtration rate of two groups of membrane members in the solution can reach 20%. That is, the flow of the liquid entering the ceramic membrane filter is $500\text{m}^3/\text{h}$; the area of the ceramic membrane is 200m^2 ; the membrane area of each filter is 50m^2 ; and only four ceramic membrane filters are required.

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Selection of the feed pump 1: two stainless steel feed pumps with a flow Q of $100\text{m}^3/\text{h}$, a head H of approximately 35m water column, and a power N of approximately 15kW.

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Selection of the recycle pump 9: two stainless steel feed pumps with a flow Q of $500\text{m}^3/\text{h}$, a head H of approximately 10m water column and a power N of approximately 23 kW.

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The height h of the filtration purified solution tank above the ground: the purified solution flowing out of the ceramic membrane filter 12 still has a pressure of $2.1\text{kg}/\text{cm}^2$, and can raise brine (concentrated solution) with the specific gravity of 1.2 to 17.5m. Therefore, a height of an upper opening of a brine overhead tank can be at 17m above the ground, and hence the power can be saved.

CLAIMS

- 5 1. A suspension clarification and filtration device, comprising a hydraulic cyclone (4), an inclined-tube settler (7), a ceramic membrane filter (12) and an auxiliary pipeline, characterized in that the auxiliary pipeline system includes a feed pump (1) and a recycle pump (9), a suspension runs through the hydraulic cyclone (4), the inclined-tube settler (7) and the ceramic membrane filter (12) in sequence and finally enters a purified solution
10 tank (15), so as to complete the whole liquid purification process.
2. The suspension clarification and filtration device according to claim 1, characterized in that the suspension runs through a liquid inlet pipe (2) by the feed pump (1) and is fed into the hydraulic cyclone (4) along a tangential direction; separated sludge enters a funnel
15 settling area and is discharged via a reject valve (3); a separator medium on an upper portion of the hydraulic cyclone (4) enters a lower portion of the inclined-tube settler (7) via a feed pipe (5); the liquid flows up and runs through inclined tubes (8), and fine particles are settled into sludge; the sludge is discharged via a reject valve (6); and a clarified supernatant enters the ceramic membrane filter (12) via a supernatant pipe (11).
- 20 3. The suspension clarification and filtration device according to claim 1, characterized in that in an operating state of the system, a concentrated solution at an outlet of the ceramic membrane filter (12) accounts for 80-90% of the feed liquid volume, is mixed with a feed liquid from the hydraulic cyclone (4) through the recycle pump (9) via a recycle
25 liquid pipe (10), and enters, together with the feed liquid, the inclined-tube settler (7) for settlement and clarification; a purified solution running through the ceramic membrane filter (12) enters the purified solution tank (15) in virtue of self hydrostatic via a purified solution pipe (14); and an exhaust pipe and an exhaust valve (13) are disposed on a supernatant pipe (11).
- 30 4. The suspension clarification and filtration device according to claim 1, characterized in that the inclined-tube settler (7) is a closed container and has a working pressure of 2-2.3kg/cm²; when a pressure difference of both sides of a filter membrane of the ceramic membrane filter (12) is less than 1kg/cm², the liquid level of the purified solution tank (15)
35 is at 9-11m above the ground.