DESCRIPTION

The present invention relates to a filtering device and to the method for cleaning such a device.

Filtering devices or filters normally used for the elimination of suspended matter contained in the fluids to be treated, such as untreated water, are constituted by beds of granular materials, such as sand, anthracite, pumice, biolite, etc. These materials have a particular density above that of the fluid to be treated and constitute a so-called fixed bed resting on a support known as the filter floor. During the filtration phase, the fluid circulates in a downward flow in said bed which remains fixed. In the remainder of the text, when reference is made to the density, this means the particular density. During this phase, the suspended materials retained by the bed bring about a deep dirtying or choking of the latter.

A washing of the filter bed at regular intervals brings about the removal of the materials retained in accordance with the two stages defined hereinafter. This washing on the one hand brings about a detachment of the retained materials and on the other the transportation of said materials to a discharge point. Generally the second stage is performed by water.

The washing phase is either carried out with a so-called fluidized bed, or with a so-called agitated bed. Washing by fluidized bed consists of washing the filter bed by water return in a rising flow at a speed higher than the minimum fluidization rate. In this case, the fixed bed in which the filtering materials were in contact with one another expands and the grains of materials kept suspended in the fluid flow no longer touch one another. Therefore, during this phase, the suspended materials are no longer retained by the grains of the filtering material and are detached.

Washing by agitated bed consists of circulating the water in a rising flow at a speed lower than the minimum fluidization rate and by simultaneously introducing air into said rising flow. The introduction of air bubbles brings about a lowering of the average density of the fluid and an agitation or stirring of the filtering materials, during which the suspended materials become detached.

In the remainder of the text a washing by water return with a flow which is the reverse to the flow corresponding to the filtering phase will be called backwashing.

Other filtering devices have what is called a fixed floating bed, which is constituted by materials, whose density is below that of the fluid to be treated and which is in general water. This bed of materials floating in water is kept immersed by means of a known blocking device, such as a grating and in this case reference is made to a fixed floating bed.

Such a device is known from GB-A-11 305 399, in which the fixed floating bed is constituted by polystyrene pellets or granules maintained in the chamber of a filter by a partition perforated with dimensions smaller than those of the granules and arranged perpendicular to the axis of symmetry of the filter chamber. Filtering takes place in the depth of the layer of granules in accordance with a rising flow and the treated water is recovered in the upper part of the filter by an orifice located close to its upper end, whilst the untreated water is introduced into the lower part of the filter below the floating bed. The filter is cleaned by backwashing reversing the fluid flow direction within the filter and using treated water flowing at a speed higher than the minimum fluidization rate in order to permit the expansion of the bed and its cleaning.

This type of depth filtering device, which is the most simple and economic from the constructional standpoint, suffers from the disadvantage of requiring a very considerable treated water quantity for the backwashing operation. This treated water quantity necessary for cleaning the filter is several times the capacity of the latter, so that this process leads to significant wastage, which is the opposite to the aim of economizing on the water consumption by recycling and treating it.

Another depth filtering device and associated processes are known from US-A-4 547 286, which teaches the use of a floating bed constituted by granules or pellets of floating materials such as polyethylene or polypropylene having a density close to that of water, namely approximately 0.9. As a washing method this document teaches the use of the agitated bed method by

introducing air into the fluid in order to reduce the apparent density of the fluid constituted by liquid and gas as compared with the granules of the floating materials. Although this process reduces the water consumption, it requires the supply of a secondary fluid or gas in order to vary the average density of the fluid, which makes the construction and operation of such a filter more complex. This process also limits the choice of filtering materials to those having a density 10 to 20% below that of the fluid to be treated.

It is also known to clean fixed floating bed filters in a rising flow by gravity backwashing. This process is disclosed by US-A-4 446 027, in which a floating bed of glass macrospheres with an average diameter of 0.7 mm and a uniformity coefficient of 1.6 is fixed below a purified fluid tank. This floating bed of limited thickness, approximately 0.3 m, is used for stopping at its surface the light materials remaining suspended in the fluid at the end of a first settling phase. In this first phase, the heavy materials settle in a settling zone of a lower tank positioned below the floating bed. In addition, outside the settling zone, the fluid in the said lower tank performs a circulatory movement causing agitation. The variable size of the balls constituting the floating bed favours the arrangement of the larger balls in the upper part of the floating bed and the smaller balls at the lower limit thereof. Thus, this arrangement reduces the possibilities of suspended materials penetrating the filter.

Backwashing is carried out by using the filtered water of the upper tank, which brings about an expansion of the floating bed and the release of suspended materials which had fixed to the lower surface layer of the floating bed. During the filtering process, this document teaches the combination of flocculation phenomena by agitation, settling and additionally filtering by a rising flow in a fixed floating bed. Due to the limited dirtying, which occurs on the surface of the bed, gravity backwashing requires little water.

The water quantity used for backwashing would certainly be much higher in the case where it was necessary to clean a filter using, as the main depth filtering means, a fixed floating bed. Thus, US-A-4 582 609 teaches the use of a fixed floating bed constituted by an agglomerate of hollow glass microspheres linked by a resin and called glass macrospheres, polymer pellets or

granules, such as epoxy resins or expanded materials such as polystyrene. The gravity backwashing of the filter is obtained by increasing the filtered fluid quantity contained above the bed, by immersing the floating bed installed in a ballast device, followed by the expulsion of the filtered water through the fixed floating bed in order to create a fluidized bed. This expulsion of filtered water is obtained by immersing the ballast-floating bed assembly. It is obvious that in this case the treated fluid quantity used for backwashing is very high and well above that given in the previous patent. Moreover, this type of device has a more complex and less economic manufacture.

In the same way, DE-A-3 433 472 teaches a fixed floating bed filtering device, in which a discharge duct is located in the vicinity of the lower end of the chamber. In this filter the floating bed is cleaned by backwashing as a result of the water quantity located between the fixing grating and the treated water discharge duct located at a significant distance above the grating, as stated on p 7, lines 19 and 20. Apart from the considerable water quantity required for washing the floating bed, said device does not permit a cleaning of the floating bed by deimmersion or emergence and defixing or detaching the bed, because means are provided for maintaining the minimum liquid level above the upper portion of the grating retaining the floating bed. Therefore cleaning is dependent on the filtered water quantity above the floating bed and the cleaning of the filter cannot take place in an integral manner, because the discharge of the suspended materials occurs above the lower end of the chamber, which is consequently never completely cleaned.

GB-A-2 021 428 teaches a floating bed filtering device having a granular material with a specific gravity of 0.015 to 0.2, which corresponds to part of the density range used in the device according to the invention. However, these floating materials are used in a different device requiring the washing of the filtering bed by agitation.

FR-A-2 538 800 teaches a biological treatment device having a pipe for the discharge of the treated water in the upper part of the chamber, a pipe for supplying the water to be treated and a mud discharge pipe in the lower part of the chamber. Balls are held by a grating in the immediate vicinity of the

upper part of the chamber. However, this device does not operate by washing using deimmersion and defixing of the floating bed, because washing water is injected from the top and the mud discharged by a pipe located above the distributing device for the water to be treated.

The present invention aims at obviating the disadvantages of the prior art and proposes a device for the depth filtering in rising flow manner in a fixed floating bed having a simple and economic construction and which does not lead to a consumption of treated water during the cleaning phases.

The first objective is achieved by the fact that the device for the rising flow filtering of a fluid to be treated constituted by a prismatic or cylindrical chamber (7) sealed at at least one lower end (15) containing filtering particles (16) with a density below that of the fluid to be treated, the particles occupying a volume permitting the depth filtration and which can reach the useful volume defined as being the volume available between the inlet of the fluid to be treated and a retaining means (12), the particles being retained by said means (12) so as to constitute a fixed floating bed, the enclosure having at its upper end (14) a pipe for the discharge of the treated fluids and at its lower end (15) a pipe (3) for the discharge of filtered suspended materials, the said pipe (3) being shaped like a lyre with a vent (5), whose upper end is positioned above the maximum level which can be occupied by the fluid in the device and having dimensions permitting a draining of the fluid column contained in the chamber at a speed exceeding the minimum fluidization rate, a pipe (1) for supplying fluid to be treated being located in a zone of the lower end of the chamber positioned below the lower level of the fixed floating bed, is characterized in that means (10) link the discharge pipe (3) with the interior of the chamber (7), the vent (5) has its upper end positioned above the maximum level which can be occupied by the fluid in the device, the filtering particles have a particular density between 5 and 500 kg/m^3, the pipe for the supply of fluid to be treated being positioned above the upper level (30) of the dirt discharge pipe (3) and the pipe (2) for the discharge of the treated fluids being located in the immediate vicinity of the retaining means (12) for the fixed floating bed and in that the fixed floating bed occupies 100% of the useful volume.

According to another feature the discharge pipe for the treated fluids is linked with the chamber by an orifice at the lower end of the chamber.

According to another feature the particular density is between 5 and 150 kg/m^3.

According to another arrangement the particular density is advantageously equal to 50 kg/m^3 and corresponds to expanded polyethylene or expanded polystyrene particles.

According to another feature, the size of the draining pipe (3) is chosen in such a way that the draining rate is between the minimum fluidization rate Vmf and eight times said rate.

According to another advantageous arrangement of the invention, the size of the draining pipe (3) is chosen in such a way that the rate is preferably approximately 1.1 to 1.5 times the minimum fluidization rate Vmf.

According to another arrangement of the invention, the device has a fluid supply pipe linked by a second valve with the lower part of the chamber for flushing the concentrate of the residual dirt at the end of the cleaning process.

According to another feature the pipe for the supply of fluid to be treated has a device for distributing the liquid phase to be treated.

According to another feature the device has a venting pipe issuing through a second valve into the upper part of the chamber.

Another objective of the invention is to propose a process for cleaning a fixed floating bed filter not requiring a treated water consumption and using an original phenomenon during a deimmersion or draining phase.

This objective is attained by the fact that the process for cleaning a rising flow filtering device in a fixed immersed bed constituted by a material having a density below that of the fluid to be treated, is characterized in

that it comprises the following stages:
venting, in the case of a closed filter, by a valve (9) of the upper part of the device,
opening by the valve (10) of the discharge pipe and draining at a speed above the minimum fluidization rate Vmf,
progressive deimmersion of the fixed bed by flushing the immersed part (160, 161) by a fluidized bed zone (161),
rinsing non-immersed particles below the pipe (1) for the supply of fluid to be treated and immersed balls (160),
closing the valve (10) of the dirty mud discharge pipe.

According to another feature of the cleaning process, the device is put back into operating condition by the following operations:
flushing the residual concentrate of the suspended materials by closing a fourth valve for the supply of fluid to be treated and opening the second valve for the supply of flushing fluid in the lower part of the chamber before closing the first valve of the dirt discharge pipe,
closing the third vent valve.

According to another feature the process for washing a filter constituted by a fixed floating material bed in the filtering phase is characterized by washing with the fluid to be treated only, without any washing pump and without any washing overpressure device, and by defixing the bed of materials during the washing phase.

According to another feature the cleaning process is characterized in that the draining speed is between the minimum fluidization rate Vmf and eight times this rate.

According to another feature the cleaning process is characterized in that the draining rate is preferably between approximately 1.1 and 1.5 times the minimum fluidization rate Vmf.

Other features and advantages of the invention can be more clearly gathered from reading the following description with reference to the drawings concerning a sealed or closed filter, wherein show:

Fig. 1 The filtering device according to the invention in its filtering phase operating state.

Fig. 2 The filtering device according to the invention during the cleaning phase according to the process of the invention.

Fig. 3 The filtering device according to the invention at the end of the cleaning phase corresponding to the rinsing stage of the cleaning process.

The depth filtering device of fig. 1 comprises a prismatic or cylindrical chamber (7) sealed at its ends by an upper cover (14) and a lower cover (15). A treated water discharge pipe (2) issues by an orifice in the cover (14) into the chamber. Throughout the remainder of the text water will be used as the fluid, but it is obvious that the invention is not limited thereto. A valve (21) on the pipe (2) makes it possible to open or close the treated water discharge. A second pipe (6) also issues into the upper part of the chamber and has a valve (9) for venting the said chamber. In the immediate vicinity of the upper cover (14) there is also a means for the physical fixing of the bed such as a grating (12) or a perforated plate maintaining the floating bed (6) in place during the filtering phase. It is obvious that the dimensions of the orifices of said physical means (12) are adapted to the dimensions of the granules or pellets of material constituting the floating bed. This material constituting the floating bed can be any material having a particular density below that of the fluid to be treated and in the present case water. A choice will be made of materials having densities between 5 and 500 kg/m^3 or a density of 0.05 to 0.5. Advantageously, there is a limitation to a range of 5 to 150 kg/m^3 and in a particular embodiment of the invention the chosen material consists of particles of expanded polystyrene or expanded polyethylene having a particular density of 50 kg/m^3or a density of 0.05. As will be seen hereinafter, this low density compared with that of water plays an important part in the cleaning phenomenon. The particles having a lower density therefore have a tendency to float and agglutinate against the physical means (12), so as to form a fixed floating bed in which the particles are in contact with one another. This fixed floating bed, constituted by the granules, can occupy

100% of the useful volume defined as the volume between the grating (12) and the water supply pipe (13). Below the lower limit of the fixed floating bed and at a certain distance from the lower cover (15) of the chamber, there is a pipe (1) for the supply of the untreated water to be treated having a valve for admitting the untreated water and a distributing device (13) penetrating the chamber and ensuring a homogeneous distribution of the untreated water to be treated. A lyre-shaped draining pipe (3) is linked by an orifice in the lower cover (15) of the chamber with the lower part of the latter. A valve (10) is responsible for allowing or blocking this link. A branch of the water supply pipe (1), upstream of the valve (8), is constituted by a branch pipe (4) for the flushing of the residual dirt concentrate linked with the chamber by a lateral orifice in the latter close to the bottom (15). A valve (11) located on the pipe (4) makes it possible, after closing or reducing the valve (8), to link the untreated water supply pipe (1) with the lower part of the chamber. The pipe (3) is vented by a vent (5), whose upper end is positioned above the maximum level which can be occupied by the fluid in the filtering device. The lyre-shaped pipe (3) extended by the vent pipe, is connected to a horizontal pipe (30) joined to a vertical discharge pipe (31). The part (30) is at a level below that of the untreated water supply pipe (1) making it possible to fix a minimum fluid level at the end of the washing operation ensuring the creation of a fluid zone and a first zone (160) constituted by floating matter in a bed, where the granules are in contact and as shown in fig. 3. The pipe (1) for the supply of the untreated water to be treated is at a level above that of the highest part of the draining pipe (3). In fig. 1 cross-ruling represents the fixed floating bed when the latter is immersed, i.e. during the filtration phase. The size of the draining pipe (3) is chosen in such a way that on opening the valve (10), the draining rate of the fluid in the chamber exceeds the minimum fluidization rate Vmf of the particles immersed in the fluid. This rate can be between Vmf and 8Vmf and is preferably between 1.1 and 1.5 Vmf, in order not to excessively increase the dimensions of the pipe (3).

During the filtering process, the untreated water is introduced by the distributor (13) and in a rising flow enters the upper part of the filter traversing the fixed floating bed in which the materials suspended in the fluid are retained by the bed. The treated water issuing by the grating (12) is discharged by the pipe (2). As the filter becomes used, the fixed

floating bed becomes dirty from bottom to top and as from a time determined by a certain pressure drop and which is indicated by a not shown pressure gauge, which measures the pressure difference at the bottom and top of the filter, the filter cleaning phase is put into effect.

The washing operation has three phases in the present invention, namely a phase of lowering the water level, a rinsing phase and a filling phase. At the end of these three phases the filter is ready to operate again. The water level is lowered by opening the valve (10) in order to discharge the washing mud and dirt and in the case of a sealed filter, the opening of the valve (9) for placing under atmospheric conditions the upper part of the enclosure in which the water level drops rapidly. The flow rate of the water level in the chamber is higher than the minimum fluidization rate and the density of the filtration particles is well below the density of the water, so that a surprising phenomenon occurs during this phase. Thus, unexpectedly, it has been found that in the column of granulated materials constituting the filter, a second zone is created, in which the granules are no longer contiguous and are under conditions close to fluidization. This second zone is represented by the reference (16) in fig. 2 and is surmounted by a third zone (162), in which the materials constituting the bed are deimmersed or drained and are in contact again. The limit of the water level is at the limit between the second zone (161) and the third zone (162). Below this second zone (161) there is a first zone (160) constituted by floating materials in a bed where the granules are in contact. During this phenomenon there is a slight expansion of the floating bed, as shown in fig. 2. Thus, in said second zone (161), a spacing is obtained between the particles which is well above that which would be obtained by expansion of the entire mass by fluidization and which could not be obtained without a significant consumption of the fluidization liquid. In the second zone (161) in which the filtering materials are defixed, the suspended materials denser than the liquid and retained by filtering granules can settle and move towards the bottom as the second zone (161) advances in the direction of the lower part of the filter chamber. During this operation, the suspended materials are discharged in the form of washing mud and dirt by the pipe (3) and at the same time as the water.

Thus, in this washing stage, use is not made of treated water. Use is made

solely of the untreated water located in the part of the filter constituted by the floating bed in order to clean the said part. At the end of the water level lowering operation, the device is in the configuration shown in fig. 3, in which a large part of the granular materials constituting the filter bed illustrated by the hatching of the third zone (161) is completely deimmersed, whereas the water level is close to the level of the highest portion (30) of the pipe (3). A small part of the filtering materials forms a residue of immersed floating bed constituted by the first zone (160), which supports the column of the third zone (162) of emerged and cleaned materials. The arrival of water through the pipe (1) and the distributor (13) is advantageously used in this phase for rinsing the deimmersed zone of floating materials located below said pipe (1) and the first immersed zone (160) in which there are still suspended materials in a larger proportion than that of the untreated water. Pipe (3) makes it possible to discharge the residual material concentrate remaining in that part of the filter below the untreated water supply pipe. In this way, the suspended material concentrate at the base of the filter is discharged. Once this rinsing operation has taken place, the valve (10) is closed and the filter again starts to fill with untreated water supplied by the pipe (1). As the water level rises, the interstitial air is entrained and the floating material (16) rises again until it is blocked by the upper grating. The upper valve (9) for bringing about atmospheric conditions permits the final discharge of air and after closing the valve (9), the filter automatically comes back into operation again.

In a constructional variant, it is possible to improve the discharge of suspended material concentrate on the filter bottom (15) by carrying out a flushing of untreated water by closing the valve (8) and opening a valve (11) in order to supply water level with the bottom (15) by means of a branch pipe (4).

In an advantageous embodiment, the supply of untreated water delivered by the pipe (1) is maintained during the water level lowering phase. This is possible because the flow rate of the untreated water delivered by the pipe (1) is five to ten times below the water discharge rate on the part of the discharge pipe (3). Consequently the maintenance or non-maintenance of the

untreated water arrival has little significance for the washing operation and avoids any need to manipulate a supplementary valve.

The washing system according to the invention and the filter thereof have the advantage of not requiring an auxiliary system for supplying clean water with a high flow rate in order to bring about washing. In the same way there is no need for an auxiliary system for supplying air so as to agitate the bed.

Finally and as has been seen hereinbefore, the washing process has the advantage of bringing about optimum usage, during the washing phase, of the natural characteristics of the floating material and the suspended matter retained during filtration. Thus, the retained suspended matter having a density above that of water naturally tends to descend by settling and is entrained by the downward flow of water. In addition, the floating material having a density well below that of the fluid to be treated naturally tends to escape from the liquid phase and contributes to the phenomenon of defixing and fluidization by creating a second zone (161), which flushes the bed during the rapid lowering of the water level. The filter is cleaned in a few seconds, which reduces to zero the treated water consumption and significantly minimizes the consumption of untreated water during said cleaning operation. Moreover, the untreated water containing a suspended matter concentrate discharged by the pipe (3) can be supplied to a settling means and can then be recycled to the filtering installation.

The description has been given in connection with a sealed or closed filter, but it is obvious that the invention also applies to the case of an open filter, in which case there is no need for the venting and vent valve closing operations.

For information purposes a comparison is given hereinafter of the results obtained with a filter according to the invention and a conventional sand filter. The tests were carried out on untreated surface water containing 26 mg/l of suspended matter (MeS) treated with ferric chloride. The materials were placed in columns with a diameter of 150 mm. The filtering layer thickness was 1 m in each case.

The materials used and the results obtained are shown in the following table:

Filter	Floating Bed	Sand
Material	Expanded polystyrene balls	Sand
T E mm	1.36	1.33
C U	1.30	1.30
d_R	51.10^{-3}	2.6
Vmf in m/h	50	70
Clean water loss	0.8 m^3/m^2	4.6 m^3/m^2
Treated water loss	2.25 m^3/m^2	6 m^3/m^2
Collected dirty water	1.75 m^3/m^2	6 m^3/m^2

Apart from the densities, the grain size characteristics of these two materials are substantially identical.

TE (effective size) = size in mm of the screen traversed by 10% by weight of the filtering materials and CU is the uniformity coefficient, d_R the real density and Vmf the minimum fluidization rate. The supply of untreated water + reagent came from a common circuit.

The regulation of the filtration regulating member is, in both cases, carried out so as to obtain 128 l/h at the outlet, i.e. a filtration speed of 8 m/h. The floating bed filter is washed in the manner described hereinbefore. The initial water discharge rate during deimmersion is 70 m/h = 1.4 Vmf.

The sand filter is washed in the following way:

5 min air blowing (55 m/h) + water (15 m/h),
10 min rinsing with water from the mains at 20 m/h and with a rising speed.

The filters are washed when the turbidity of the filtered water reaches 1 NTU.

In conclusion, for comparable filtration results obtained with the two materials, floating bed filter and sand filter, the following summary can be given:
minimum turbidity of filtered water = 0.3 to 0.4 NTU,
a final turbidity of the filtered water of 1 NTU corresponding to a suspended matter retention of 1.7 kg/m^2 and a pressure drop of 0.8 m water column, the clean water losses are six times less with the invention, the treated water losses are at least three times greater with the invention, the production of dirty water is 3.5 times less than that of the sand filter and the invention does not consume air.

It should also be noted that the principle of the invention is completely different from that of US-A-4 446 027, in which the water to be treated contains 300 mg/l of suspended matter, the filtration rate is 5 m/h, whilst the pressure drop at the end of the cycle is only 0.05 m. This means that with water containing more matter, there is no depth dirtying of the filter and with a low pressure drop, because a significant part of the materials settles as a result of the lower filtration speed. Unlike in the case of the invention which does not use settling and uses the entire depth of the floating bed for filtration purposes, US-A-4 446 027 only uses a surface effect.