

The invention relates to a rack arrangement for separating solids out of liquids, for example for sewage treatment plants, with cleaning elements revolving in a rack frame which extend substantially over the width of the frame and are connected to at least one lateral endless chain which is driven by a motor.

Such rack arrangements are used for example in the intakes of sewage treatment plants, but also in industrial operations, in order to clean liquids containing solids and/or solid particles of these solids.

These rack arrangements usually have rods arranged like a grid in a frame which substantially fills the cross-section of the intake, these rods being provided in a steeply inclined arrangement, cf. for example CH 382 670 A, US 2 106 851 A or US 5 730 862 A. In these known rack arrangements comb-like cleaning elements are fixed, spaced from one another, on lateral endless chains in order to convey the solids left caught on the rods to the rack head; in the region of the rack head a rack material discharge is provided where the solids collected are discharged and are led off for example to the side.

Thus in these known rack arrangements the functions of separating out the solids, on the one hand, and transporting away the solids which have been separated out, on the other hand, are carried out by various components; the result of this is that problems repeatedly occur of keeping the spaces clear between the rods which perform the separating or screening function. Above all, the comb-like cleaning elements can become caught at blockage points, which can lead to overloading of the drive motor for the endless chains. In this connection, therefore, mechanical and electronic safety devices have already



been proposed in order to free these types of blockages on the rack rods by multiple to-and-fro movement of the comb-like cleaning elements. Apart from the structural expense necessary therefor, the known rack arrangements still operate with only limited reliability.

The object of the invention, therefore, is to create a rack arrangement of the type set out in the introduction which whilst being of simple construction reliably prevents blockage or dislocation and facilitates efficient cleaning during operation. The invention is therefore based on the idea that when the aforementioned functions of separating out and transporting away are carried out by one and the same component a new type of cleaning can be provided, so that blockage of the rack arrangement is reliably prevented and its permeability is ensured. The latter is essential since otherwise damming of the liquid in front of the rack arrangement could lead to an overflow of the liquid in the intake area.

The rack arrangement according to the invention, of the type set out in the introduction, is characterised in that step-like screen elements which have a perforation and are disposed like an escalator are provided as cleaning elements, and that in the upper region of the rack frame there is provided a screen element cleaning device with nozzles for cleaning the perforated screen elements as they move past.

In the present rack arrangement (in which there is no longer a "rake" in the literal sense, with rake prongs, but for which the term "rack arrangement" is used below because this term has been introduced in general for the most varied types of cleaning devices, particularly in sewage treatment plants), the perforated



screen elements perform not only the function of separating out the solids but also of transporting away these solids towards the rack head. The solids are separated out due to the perforation of the screen elements, the holes being of such a size that the liquid can pass through the screen elements but the solids beyond a certain size are retained. The solids separated out in this way are transported upwards with the aid of the steps of the screen elements on the upstream side of the rack arrangement, and at the top reversal point of the rack arrangement, on the rack head, where the screen elements change their position by 180°, these solids are discharged and are then led off at the sides. After that, the step-like screen elements in the rack arrangement according to the invention are cleaned with the aid of the nozzles, so that the holes in the screen element – if any solids have become attached there – are freed again; accordingly, after passing the lower reversal point, the perforated screen elements can in turn separate out the solids from the liquid in the upstream segment during the upward movement and transport them upwards, without any fear of blockage of the screen elements and thus of the rack arrangement as a whole. In this case the nozzles can be connected to a pump via pipe or hose lines which deliver the cleaning liquid, particularly water, so that the nozzles can clean the perforated screen elements with the water jets discharged.

The nozzles themselves can be placed outside the actual rack arrangement, i.e. outside the screen elements which move up and down like an escalator, in order to spray the perforated screen elements from the outside. However, this leads to the solids collecting in the internal space between the revolving screen elements, and these solids must be removed at least periodically from this internal space, which can be expensive in construction terms. It has therefore proved



advantageous if the nozzles are placed in the internal space in the rack arrangement defined between the upstream and downstream screen elements and are generally directed towards the downstream rear face of the rack arrangement in order to clean the perforated screen elements from the inner or rear face. As a result the solids are washed off from the screen elements towards the exterior to the downstream side, so that the space inside the rack arrangement is not loaded with solids.

The solids can be washed directly into the liquid behind the rack arrangement, which could then be reliable if further cleaning and precipitating stages follow in the liquid flow. However, this construction with the nozzle-cleaning device on the rack head and the construction of the rack arrangement with step-like screen elements advantageously offers the possibility of collecting the solids washed off from the screen elements along with the cleaning liquid containing them in an efficient manner and not allowing them to enter the liquid behind the rack arrangement. Accordingly, one preferred embodiment of the rack arrangement according to the invention is characterised in that on the outside of the downstream segment of the screen elements there is provided a collecting wall or cup to catch cleaning liquid sprayed by the nozzles on the rack frame. In this construction the solids washed off from the step-like screen elements with the cleaning liquid are collected and led off, and they can also be returned to the front of the rack arrangement, so that with the aid of the screen elements they can be separated off there ultimately and can be finally discharged at the rack head. In this connection a simple construction has proved favourable in which a return line leading to the upstream side of the rack arrangement is connected to the collecting wall or cup. The return line can be inclined from the rear face of



the rack arrangement to the front face thereof, so that the cleaning liquid with the washed-off solids flows by itself to the front face of the rack arrangement.

The nozzles could be disposed in a single line transversely with respect to the direction of movement of the screen elements; however, in order to achieve particularly effective cleaning, the nozzles can also be connected one after another in the direction of movement of the screen elements and accordingly it is favourable if the nozzles are placed on two or more nozzle beams.

The nozzles can be arranged close beside one another in the transverse direction, and/or they can also be constructed as flat nozzles which discharge fanned jets; however, in order to be able to clean the screen elements reliably with a relatively low throughput of cleaning liquid, it has proved particularly advantageous to provide relatively few nozzles, but to place them so that they are movable in order in this way to spray the screen elements reliably with relatively thin, strong jets each directed over one area of the screen elements. Accordingly one advantageous embodiment of the present rack arrangement is characterised in that the nozzle beams are disposed so that they are movable to and fro, e.g. pivotable, in a transverse direction with respect to the direction in which the screen elements revolve. In this case, moreover, an efficient driving facility is provided in that the nozzle beams are connected to one another by way of a rod articulated on them and to a motor by way of a crank drive.

As already mentioned, one particular aim has been to clean the screen elements with few nozzle jets, and in this connection it has proved advantageous if the nozzles are constructed as high-pressure nozzles, for example designed for a



pressure from 15 to 20 bar. In this way the cleaning time per unit of surface of the screen elements can be kept extremely short, and reliable cleaning of the screen elements and their holes can nevertheless be guaranteed.

In order to help lead off the solids in the region of the rack head and to carry out a kind of pre-cleaning of the screen elements before they are sprayed with the aid of the nozzles, it has also proved advantageous if the screen element cleaning device has a cleaning brush for the screen elements in the region of the solids discharge adjacent to the upper screen element reversal point. In this case the cleaning brush can be constructed as a stationary brush extending over the width of the rack arrangement against which the screen elements brush as they pass by. However, in order to achieve reliable pre-cleaning in the region of the inner step angle of the screen elements as well, it is particularly advantageous if the cleaning brush is a motor-driven rotating brush.

The present construction of the rack arrangement with the step-like screen elements and the nozzle-cleaning device also advantageously offers the possibility of being able to react quickly and automatically to a fluctuating load of solids in the liquid, for which only quite simple measures are necessary. Accordingly it is advantageous if a control circuit connected to liquid level sensors disposed upstream and downstream of the rack arrangement is associated with the motor driving the screen elements by way of the endless chain, the motor being adjustable to a higher speed in the event of an increasing level difference. Therefore in this rack arrangement, if it happens that the level of liquid in front of it rises because of the high load of solids by comparison with the level of liquid behind the rack arrangement, this is detected by the sensors,



and the motor for the endless chains is caused to turn at a higher speed by the control circuit. Accordingly the step-like screen elements then revolve faster, so that faster separation of solids from the liquid takes place, and in turn more liquid can flow through the rack arrangement, so that in turn an adaptation of the level takes place upstream and downstream of the rack arrangement. In this case the control circuit can be designed so that at the same level upstream and downstream of the rack arrangement the speed of the motor is adjusted back far enough until a slight level difference is detected again.

The invention is explained in greater detail below with reference to especially preferred embodiments which are illustrated in the drawings, but it should not be limited to them. Figure 1 shows a front view of a rack arrangement, shown schematically, inserted in an intake or gutter; Figure 2 shows an appertaining side view of this rack arrangement, wherein one side wall of the intake and the adjacent side part of the rack frame have been omitted; Figure 3 shows a schematic side view of the rack head on an enlarge scale relative to Figure 2, without the different individual parts such as screen elements and rotating brush; Figure 4 shows a front view of a cleaning and/or screen element for the present rack arrangement; Figure 5 shows an appertaining side view of this cleaning and/or screen element according to the arrow V in Figure 4; Figure 6 shows a view of part of an endless chain of the present rack arrangement to illustrate the bolts which serve to fix the screen elements according to Figures 4 and 5 on the chain sections; Figure 7 shows schematically in a partial view a nozzle unit for attachment in the region of the rack head; Figure 8 shows a cross-section through this nozzle unit along the line VIII-VIII in Figure 7, but on an enlarged scale relative to Figure 7; and Figure 9 shows a block diagram of a control circuit for



the electric motor driving the endless chains of the rack arrangement, in conjunction with a schematic representation of the rack arrangement.

Figures 1 and 2 shows a rack arrangement which is generally designated by 1 and is also referred to below as a filter step rack, and which is used in a generally upright position in an intake or gutter 2, which is for example concreted, for a liquid which contains solids and is to be cleaned of the latter; however, as can be seen from Figure 2, the rack arrangement 1 is disposed in the flow direction, see the arrow 3 in figure 2, rising below 60° to the horizontal. For example, the intake 2 can be an intake to a sewage treatment plant or to equipment for cleaning liquids in industrial plants.

The rack arrangement 1 has a rack frame 4 which consists of two side parts 5, 6 which are connected to one another on the front and rear face by a plurality of transverse struts 7. These transverse struts 7 are distributed spaced from one another over the height of the rack arrangement 1, cf. also in particular Figure 2. Chain guide rails which are not shown in greater detail are provided on the inner faces of the frame side parts 5, 6 for guiding a lateral endless chain 8 in each case, which is only indicated schematically in Figure 2, and of which a detail is shown in top view in Figure 6. These endless chains 8 are in each case guided in a manner which is known *per se* over an upper chain wheel 9 and a lower chain wheel 10, these chain wheels 9, 10 being rotatably mounted in the rack frame 4. The upper chain wheel 9 is driven in a manner which is equally conventional *per se* by a motor 11, particularly an electric motor, and naturally a corresponding gear box (not shown) can be provided in the usual way.



Perforated screen elements 12, also known as "rake elements" are fixed on the endless chains 8 as rack-cleaning elements, these screen elements 12 being bent like steps and disposed like an escalator on the endless chains 8, as can be seen in particular from Figure 2. In this case these screen elements 12 together form on the inflow side - i.e. the upstream front face of the rack arrangement 1 (the left-hand side in Figure 2) - a practically uniform screen surface, as can also be seen from Figure 1; in this case the screen elements 12 are constructed with a regular perforation both on the upright surface and also on the horizontal step surface.

As can be seen in Greater detail in Figures 4 and 5, the individual screen elements 12 are formed by triply bent screen plates 13, the rows of holes of which are staggered with respect to one another by a half-hole division in each case, so that an arrangement of holes 14 is achieved corresponding to equilateral triangles, as can be seen in Figure 5. In this case the holes 14 can have a diameter for example of the magnitude of several millimetres, for example 4 millimetres. Furthermore, the plates 13 are firmly connected to side plates 15 on both front faces, for example by welding. These side plates 15 have bores 16, 17 with which they are fixed to bolts 18, 19 on the individual chain links 20 of the respective endless chain 8, cf. also Figure 6. The screen elements 12 extend over the whole width of the rack arrangement 1, i.e. over practically the width of the intake 2, wherein this width or the length of the screen elements 12 can be 1 to 1.5 m, for example 1.2 m.

In operation the liquid from which the solids are to be separated out flows in the direction of the arrow 3 in Figure 2 against the rack arrangement 1, wherein the

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solids – above a certain particle size predetermined by the size of the holes – are separated out with the aid of the perforated screen elements 12, whereas the liquid itself can flow through the rack arrangement 1. The solids which have been separated out collect on the horizontal step surfaces of the screen elements 12 which are disposed like an escalator and are conveyed upwards to the rack head 21 by the continually revolving screen elements 12. There the upper chain wheels 9 define a reversal point for the endless chains 8 and accordingly for the screen elements 12, and the solids are discharged at 22 (rack material discharge) by the screen elements 12 due to their 180° turn. After that the solids are removed laterally, which is conventional *per se* and is not shown in greater detail in the drawings.

Figure 3 shows the rack frame 4 in the region of the rack head 21, where on endless chain 8 and one upper chain wheel 9 are also shown by dash-dot lines. The rack material discharge 22 is also shown, and moreover one of two symmetrically disposed rear lateral mounting plates 23 can be seen which serve for mounting of a rotating brush 25 (see Figure 2) which is disposed on the rear face of the rack head 21 and is driven by a motor 24. For this purpose the mounting plates 23 have a mounting opening 26. The mounting plates 23 are also connected to a rear hood cover 27 which is bent in the shape of a polygon and which together with the mounting plates 23 is articulated as a unit by way of a hinge joint 28 on an upper cover 29 of the rack head 21. In this way the unit with the mounting plates 23 and the hood cover 27 can be folded away backwards or upwards after a clamping closure 30 has been opened, if this is necessary for maintenance or repair work.

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Finally, Figure 3 shows the upper part of a collection cup or wall 31, see also Figure 2, the purpose of which is to collect the cleaning liquid, particularly water, discharged by a nozzle unit 32 (see Figure 2 as well as Figures 7 and 9) together with solids washed off from the screen elements 12 on the rear face of the rack arrangement 1. A return line 33 which is inclined and can be seen from Figures 1 and 2 is connected laterally to this collection cup or wall 31 and returns the cleaning liquid, together with the solids which have been washed off, back to the front face of the rack arrangement 1.

Thus the rotating brush 25 and the nozzle unit 32 together form a screen element cleaning device which is illustrated generally by 34 in Figure 2 and is disposed in the region of the rack head 21 in order effectively to clean the cleaning elements provided in this filter step rack 1, namely the screen elements 12, which perform both a screening function and also a transport function, at a location above the level of the liquid. As can be seen from Figure 2, the nozzle unit 32 is preferably located in the internal space 35 between the front working segment of the endless chains 8 together with the screen elements 12 indicated at 36 in Figure 2 and the rear return segment 37.

Finally, Figure 2 shows an inspection opening 38 through which the nozzle unit 32 as well as the collection cup 31 (and naturally other components such as the endless chains 8 and the screen elements 12) can be inspected.

According to Figures 7 and 8, a transverse support 29 extending over the width of the rack is fixed on the frame side parts 5, 6, for example by means of bolts 40, three nozzle beams 42 being pivotably fixed on this transverse support 39 by



means of mounting bolts 41. Each of these nozzle beams 42 has two nozzles 43, one at each of its ends, these nozzles being connected via hose lines (not shown in greater detail) to distributor pipes 44 which are fixed on the transverse support 39, preferably via pipe fittings 45, as can be seen in particular from Figure 8.

The three nozzle beams 42 are flexibly connected to one another by way of a rod 47 connected to them by bolts 46, and a crank drive which is illustrated schematically at 48 and is driven by a motor 49 engages on one of the nozzle beams 42, the right-hand nozzle beam 42 in Figure 7, in order to pivot the nozzle beams 42 together about their respective articulation points (mounting bolts (41), cf. also the double arrow 50 in Figure 7.

Figures 7 and 8 also show sleeves welded into the nozzle beams 42 as nozzles 43; naturally, however, these sleeves can serve to receive separate nozzle elements having particularly small nozzle orifices, but this is not shown in greater detail in the drawings.

In operation the motor 49 drives the first nozzle beam 42 via the crank drive 47 with the drive rod 51, and thus the first nozzle beam is pivoted about its mounting bolts 41, and thus drives the other two nozzle beams 41, likewise pivoting to and fro by way of the rod 48. In this way the nozzles 43 are moved to and fro in a circle, as shown by the arrow 49 in figure 7, so that they cover the whole width of the filter step rack 1 between the side frame parts 5, 6 on two levels and thus can each clean approximately one third of the rack width, i.e. one third of the length of the screen elements 12.



In this case the nozzles 43 are high-pressure nozzles to which water is fed at a pressure of for example 15 to 20 bar, particularly 18 bar, in order to spray the screen elements 12 and the holes 14 thereof to spray them free of any solids. Beforehand the screen elements 12 and hence also the holes 14 thereof are cleaned with the aid of the rotating brush 25 shown in Figure 2, the solids brushed off of the screen elements 12 with the aid of the rotating brush 25 being fed to the rack material discharge 22 for ultimate removal. By contrast, the solids washed out of the holes 14 in the screen elements 12 with the aid of the spray jets are collected – together with the water – in the collection cup 31 and are returned to the front face of the rack.

Even though it is not shown in greater detail in the drawing in Figure 2, in the region of the lower reversal point of the filter step rack 1, i.e. radially outside the lower chain wheel 10, stationary brush elements are provided in order to brush off and clean both lateral endless chains 8, on the one hand, and the screen elements 12 on the other hand.

Figure 2 also shows two liquid level sensors 52, 53 quite schematically, wherein one, 52, is disposed upstream of the filter step rack 1 and the other, 53, is disposed downstream thereof. These liquid level sensors 52, 53 detect the level of the liquid upstream and downstream respectively of the rack arrangement 1, and they are connected to a control circuit for the chain drive motor 11 in order, in the event of a difference in the level which occurs when the liquid flowing in has a high load of solids and the liquid dams up on the front face of the filter step rack 1, to cause the motor 11 to turn at a higher speed. The corresponding control circuit 54 is explained in greater detail below with reference to Figure 9.



As can be seen from Figure 9, the control circuit 54 is connected to the upstream level sensor 52, on the one hand, and to the downstream level sensor 53, on the other hand, (see also the arrow 3 indicating the flow direction of the liquid), the output signals of the two sensors or measuring elements 52, 53 being fed to a measuring transducer 55. For example the sensors 52, 53 can be pressure sensors which detect the hydrostatic pressure on the basis of the liquid located above them, and in the measuring transducer 55 the signals emitted by the sensors 52, 53 are transformed in a manner which is known *per se*, are amplified and advantageously put into digital form. The difference between the measured values emitted is formed, which can either take place in the measuring transducer 55 or advantageously in a processor 56 which is connected after the measuring transducer 55 and in the latter case receives both measurement signals delivered from the two sensors 52, 53 in processed form.

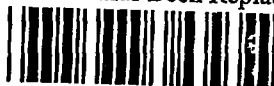
In a storage area which is not shown in greater detail the processor 56 contains predetermined desired values for the rack speed, i.e. the speed of the motor 11, and depending upon the determined differential measured values it emits a control signal to control the motor speed, which in the present example is delivered to a frequency transformer 57. According to this control signal the frequency transformer 57 applies a voltage with a variable frequency to the drive motor 11. The drive motor 11 may for example be a conventional three-phase motor which is set for a nominal frequency of 50 Hz, control being possible in the range from 30 to 90 Hz. Accordingly the speed can be controlled by way of this frequency control. The speed can be infinitely controlled by the frequency transformer 57 between two limiting frequencies, a minimum frequency of for



example 30 Hz and a maximum frequency of for example 60 Hz, but it is also conceivable to switch the frequency in stages or to use a type of two-point control with only two possible speeds, one corresponding to the minimum frequency (e.g. 30 Hz) and the other corresponding to the maximum frequency (e.g. 60 Hz).

In addition to supplying voltage with adjustable frequency, the frequency transformer 57 can also be used for overload control, since depending upon the load on the drive motor 11 a current is drawn from it which can be detected in the frequency transformer 57. For example, current values in the range from 2A to 7A are conceivable, and when the drive motor 11 is assumed to have a nominal current of 3A, if this nominal current is exceeded by for example 10% an alarm signal can be emitted and/or an emergency shut-off can take place. The alarm signal can also already be emitted when the maximum speed is reached (for example when controlling the speed corresponding to the maximum frequency of 60 Hz).

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Claims



1. Rack arrangement for separating solids out of liquids, for example for sewage treatment plants, with cleaning elements revolving in a rack frame which extend substantially over the width of the frame and are connected to at least one lateral endless chain which is driven by a motor, characterised in that step-like screen elements (12) which have a perforation (14) and are disposed like an escalator are provided as the cleaning elements, and that in the upper region of the rack frame (4) there is provided a screen element cleaning device (34) with nozzles (43) for cleaning the perforated screen elements (12) as they move past.
2. Rack arrangement as claimed in Claim 1, characterised in that the nozzles (43) are placed in the internal space (35) in the rack arrangement (1) defined between the upstream and downstream screen elements (11) and are generally directed towards the downstream rear face of the rack arrangement (1) in order to clean the perforated screen elements (12) from the inner or rear face.
3. Rack arrangement as claimed in Claim 2, characterised in that on the outside of the downstream segment (37) of the screen elements (12) there is provided a collecting wall or cup (31) to catch cleaning liquid sprayed by the nozzles (43) on the rack frame (4).
4. Rack arrangement as claimed in Claim 3, characterised in that a return line (33) leading to the upstream front face of the rack arrangement (1) is connected to the collecting wall or cup (31).

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5. Rack arrangement as claimed in one of Claims 1 to 4, characterised in that the nozzles (43) are placed on two or more nozzle beams (42).
6. Rack arrangement as claimed in Claim 5, characterised in that the nozzle beams (42) are disposed so that they are movable to and fro, e.g. pivotable, in a transverse direction with respect to the direction in which the screen elements (12) revolve.
7. Rack arrangement as claimed in Claim 6, characterised in that the nozzle beams (42) are connected to one another by way of a rod (48) articulated on them and to a motor (49) by way of a crank drive (47).
8. Rack arrangement as claimed in one of Claims 1 to 7, characterised in that the nozzles (43) are constructed as high-pressure nozzles, for example designed for a pressure from 15 to 20 bar.
9. Rack arrangement as claimed in one of Claims 1 to 8, characterised in that the screen element cleaning device (34) has a cleaning brush (25) for the screen elements (12) in the region of the solids discharge (22) adjacent to the upper screen element reversal point.
10. Rack arrangement as claimed in Claim 9, characterised in that the cleaning brush (25) is a motor-driven rotating brush.
11. Rack arrangement as claimed in one of Claims 1 to 10, characterised in that a control circuit (54) connected to liquid level sensors (52, 53) dispose



upstream and downstream of the rack arrangement (1) is associated with the motor (11) driving the screen elements (12) by way of the endless chain (8), the motor (11) being adjustable to a higher speed in the event of an increasing level difference.



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