

Wastewater heat exchanger

The invention relates to a wastewater heat exchanger which, in a housing with inlet and outlet for the wastewater, comprises a substantially cuboid package of cylindrical tubes arranged parallel
5 to and below one another and through which a heat-absorbing fluid flows, and a cleaning device for the tube jackets, which is suspended above the tube package in the longitudinal direction of the tubes and is provided with retaining elements hanging down between the tubes from a support, which carry elastic lips that sweep over the tube jackets.

10 Such a wastewater heat exchanger is known from DE102008 001 518 A1. In this device, the essentially semicircular lips, which sweep across the tube jackets and scrape off the deposited dirt layers (biofilms, sewer membranes), are pressed onto the tube surface from opposite sides perpendicular to the respective tube axis. The contact pressure of the lips is therefore greatest in the center of the semicircle but decreases towards the ends of the semicircle to zero, resulting in
15 an uneven and unsatisfactory scraping effect. Furthermore, the ends of the lips that rest against the tubes deflect in the opposite direction of movement during the reciprocating motion of the cleaning device, which also impairs the scraping effect. Another disadvantage of the known wastewater heat exchanger is that the support for the retaining elements for the scraper lips is mounted on rollers on rails running longitudinally along the tubes on both sides of the tube
20 assembly and requires a separate drive for the reciprocating motion. This entire mechanism is located above the water's surface because it needs to be protected from contamination due to its moving parts and therefore requires a relatively large amount of space.

The object of the invention is therefore a wastewater heat exchanger that does not suffer from the
25 aforementioned disadvantages, thus ensuring reliable and complete cleaning of the tube jackets and enabling a compact design.

This object is achieved according to the invention with a wastewater heat exchanger of the type mentioned above in that each lip has a finger engaging between two superimposed tubes and is
30 fixed in the retaining element at an angle of 5 to 30° to the longitudinal direction of the tubes, whereby adjacent fingers cover at least half a tube jacket and the ends of the fingers are curved in the longitudinal direction of the tubes, and that in each retaining element two oppositely

directed lips are attached, which each sweep over laterally adjacent tubes, and that the support of the retaining elements is connected to a single guide extending in the longitudinal direction of the tubes.

5 Because the lips engage with their fingers between the tubes at an angle of 5 to 30°, meaning they don't strike the tube surface perpendicularly, they conform to the respective tube jacket in a slightly curved, tensioned position during use. This constant pressure on the tube surface ensures that any dirt buildup on the tube jacket is reliably removed. This is further enhanced by the fact that adjacent fingers encompass at least half of the tube jacket, ensuring that no part of the tube
10 jacket remains untouched by a finger. Due to the lips pointing in opposite directions in pairs, the fingers resting on the tube jackets are subjected to pressure and friction depending on the direction of movement of the cleaning device, once under pressure and once under tension, but always with a so far unprecedented contact force that ensures the complete removal of all deposits from the tubes. Finally, the movability of the cleaning device, i.e., the support for the
15 retaining elements, on just a single guide allows for a compact design, even in greywater environments. The susceptibility to movement blockage of the cleaning device is therefore minimized.

For ease of installation, it is advantageous to combine several lips into a common lip band, with
20 the distance between adjacent fingers corresponding to 1.25 to 2.0 times the outer diameter of the tubes. This distance, measured from finger center to finger center, ensures optimal twisting and conforming of the elastic fingers to the tube surface when installed. For the same purpose, it is beneficial if the length of the fingers corresponds to 2 to 3.25 times the outer diameter of the tubes. Furthermore, for the scraping process, it has proven effective if the width of the fingers at
25 their free end corresponds to 0.25 to 1.0 times the outer diameter of the tubes.

In order to improve the elasticity and conformability of the fingers, and thus their scraping action, it has proven advantageous for each finger to have a longitudinal slot whose length corresponds to 0.5 to 3 times and whose width to 0.05 to 0.4 times the outer diameter of the
30 tubes. The adaptability of the fingers to the tube surface is further improved if each lip at the base of the finger has least one recess.

To secure the lips or lip bands pointing in opposite directions, it has proven effective to have the retaining elements feature clamping strips between which they are held. This greatly simplifies the replacement of worn lips or lip bands with new ones.

- 5 A particular advantage is that the support of the retaining elements is no longer supported on both sides of the tube package by rollers running in guide rails, but that the guide of the support of the retaining elements consists of a stationary, rotatably mounted threaded spindle that passes through a threaded nut connected to the support. Depending on the direction of rotation of the threaded spindle, the support for the retaining elements, and thus the cleaning device, can be
10 moved back and forth along the tube package. Anchoring the support with the threaded nut on the threaded spindle is sufficient in itself, as the retaining elements hanging between the tubes are stabilized in every position of movement by the fingers that sweep over the tubes. The threaded spindle-threaded nut drive system can even come into contact with greywater without risk of jamming and requires no additional bearings. However, it is advantageous to provide
15 sliding bearings surrounding the threaded spindle on both sides of the threaded nut, preferably with a plastic sliding layer. For a plastic sliding layer offers good dry-running properties and resistance to chemicals and wastewater. In this case, therefore, neither lubrication of the bearings nor sealing against grey water is required.
- 20 When sliding bearings are present on both sides of the threaded nut, it has been found that their length should each be approximately 1/10 of the tube length. This is because, with typical dimensions of wastewater heat exchangers (approximately 2.6 m long, 0.82 m high, and 1.6 m high), the point of force application when the support is moved is located roughly halfway up the retaining elements, making the bearing length of the sliding bearings statically and dynamically
25 optimal.

To ensure a rigid connection between the support and the sliding bearings, it is advantageous if each sliding bearing is supported by a strut on the support. Ideally, the strut should form an angle of approximately 30° with the sliding bearing.

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The invention is explained in more detail below with reference to a preferred embodiment. The figures show:

Fig. 1 Front view of a wastewater heat exchanger according to the invention with the cover and front wall of the housing removed,

5 Fig. 2 top view of the wastewater heat exchanger according to Fig. 1 with the housing cover removed,

Fig. 3 oblique view of the wastewater heat exchanger according to Figs. 1 and 2 without cover and front wall,

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Fig. 4 oblique view of the wastewater heat exchanger according to Figs. 1 and 2 with cover and front wall,

Fig. 5 enlarged detail A of Fig. 1,

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Fig. 6 enlarged detail B of Fig. 2,

Fig. 7 oblique view of detail A from Fig. 5,

20 Fig. 8 enlarged oblique view of part of the tubes shown in Fig. 3,

Fig. 9 top view of the cutaway of a lip band,

Fig. 10 enlarged detail C from Fig. 1

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The wastewater heat exchanger 1 according to Figures 1 to 4 has a housing 2 with an inlet 3 (in Figure 4, two connections of the inlet 3 are shown) and an outlet 4 for wastewater. The outlet 4 extends upwards from the bottom of the housing 2, which also contains a cleaning drain 5, to the level of a safety overflow 6.

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Housing 2 accommodates a substantially cuboid package 7 of cylindrical tubes 8 arranged parallel to and below one other and connected in a serpentine manner, through which a heat-

absorbing fluid, for example a brine, flows, which is supplied and removed via fluid connections 9.

The housing 2 contains a cleaning device for the jackets of the tubes 8. This device is suspended
5 above the tube package 7 so as to be slidable in the longitudinal direction of the tubes 8 and has retaining elements 11 hanging from a support 10 between the tubes 8, which carry elastic lips 12 that sweep over the tube jackets.

The movable suspension is ensured by a single guide extending longitudinally along the tubes 8
10 in the form of a stationary, rotatably mounted threaded spindle 14 equipped with a drive 13 and a threaded nut 15 encompassing this spindle and connected to the support 10 (see in particular Fig. 10). The threaded spindle 14 is provided, for example, with a drive thread, preferably a trapezoidal thread. As can be seen from Figs. 5 to 9, each lip 12 has a finger 16 engaging between two superimposed tubes 8 and is fixed in the retaining element 11 at an angle α of 5 to
15 30° relative to the longitudinal direction of the tubes 8. Adjacent fingers 16 each encompass at least half of the tube jacket, and the ends of the fingers 16 are bent in the longitudinal direction of the tubes 8. This is most clearly shown in Fig. 6: without contact with the tubes 8, the lips 12, including the fingers 16, would assume the position indicated by the dashed lines; however, in contact with the tubes 8, they are held against them under tension with a twisting motion. This is
20 the essential advantage and improvement over the prior art, as it achieves an optimal scraping effect on the dirt deposits covering the tube jackets. Two lips 12 pointing in opposite directions are attached to each retaining element 11, each sweeping over laterally adjacent tubes 8, as is most clearly shown in Figs. 6 and 8. Since the fingers 16 each encompass at least half the circumference of a tube, each tube 8 is completely scraped during a back-and-forth movement
25 of the cleaning device, with the fingers 16 being either slightly compressed or slightly stretched depending on the direction of movement: i.e., their arc of curvature is sometimes reduced and sometimes lengthened. However, in every direction of movement, the lips 12 and fingers 16 make full contact with the respective tube surface, thus ensuring the safe scraping of any coating.

30 As can be seen in Fig. 9, several lips 12 can be combined into a common lip band 17, which simplifies assembly and disassembly in a cost-effective manner. The lips 12 and lip bands 17 are made of an elastic material, for example PE or PP, with heat and corrosion resistance suitable for

the respective application. In tests, it proved advantageous to dimension the distance a between adjacent fingers 16 to 1.25 to 2.10 times the outer diameter of the tubes 8. For the length l of the fingers 16, 2 to 3.25 times the outer diameter of the tubes 8 has proven effective. For the width b of the fingers 16 at the free finger end, an optimum was found to be 0.25 to 1.0 times the outer diameter of the tubes 8.

To allow the fingers 16 to fit snugly between adjacent tubes 8 without jamming, they are provided with a longitudinal slot 18 that promotes their flexibility. The length of this slot corresponds to 0.5 to 3.0 times the outer diameter of the tubes 8, and the width to 0.05 to 0.4 times. To increase flexibility, each lip 12 has at least one recess 19 at the base of the finger 16. Figures 5, 7, and 9 illustrate two such recesses 19 each.

As can be seen in Figures 6 and 8, each retaining element 11 has clamping strips 20 between which the lips 12 or lip bands 17, pointing in opposite directions, are received. The replacement of worn lips 12 or lip bands 17 can thus be carried out in a highly efficient manner.

Although the threaded nut 15 is sufficient for guiding the support 10 of the retaining elements 11 on the threaded spindle 14, it is more advantageous to provide sliding bearings 21 on both sides of the threaded nut 15, which better support the cleaning device during its reciprocating movement on the threaded spindle 14. This is because the point of application of the resulting force on the support 10 and the retaining elements 11 is located approximately halfway up the housing 2, which generates a torque that must be absorbed by the sliding bearings 21 and the threaded nut 15. Preferably, the sliding bearings 21 are provided with a chemically resistant plastic coating, so that, on the one hand, no separate lubrication is required, and on the other hand, the entire moving unit (threaded spindle 14, threaded nut 15, sliding bearings 21) can come into contact with the wastewater.

Based on experience with a prototype, the longitudinal extent of each sliding bearing 21 is approximately 1/10 of the length of the tubes 8. To support the fastening of the sliding bearings 21 to the threaded nut 15, both are supported on the support 10 by a strut 22, whereby it is recommended that each strut 22 forms an angle of approximately 30° with the associated sliding bearing 21.

During operation, warm or hot wastewater enters the housing 2 through the inlet 3, flows around the tubes 8 of the tube package 7, and exits as cold wastewater through the outlet 4; in the event of a blockage, it can also escape through the safety overflow 6. The fluid flowing through the tubes 8 absorbs the heat of the wastewater and transfers it to the service unit via the fluid connections 9. Depending on the degree of contamination of the wastewater, the cleaning device is activated at certain intervals by the drive 13, by rotating the threaded spindle 14. This causes the threaded nut 15, along with the attached support 10 with retaining elements 11 and lips 12 (or lip bands 17), to move back and forth depending on the direction of rotation. The fingers 16, which grip the tube jackets, are subjected to both tensile and shear stresses, reliably scraping the tube surfaces. The scraped-off tube deposits that sink to the bottom are removed through cleaning drain 5.

A wastewater heat exchanger according to the invention can, for example, have the following specifications:

Dimension: 2.6m x 0.82m x 1.6m

Nominal heat exchanger surface area: 32 m²

Wastewater volume: 2-15 m³/h

Wastewater temperature: 10-100°C

Power: 10-200kW

At this size, housing 2 can be made of plastic. Larger modules are typically housed in concrete containers. It is, of course, possible to combine several modules or accommodate them in a single housing. It is essential that the cleaning device is suspended by means of a threaded nut on a threaded spindle, the drive of which is located outside the housing, and that elastic lips are provided for scraping the tube jackets, which are positioned at an angle to the tube axis and whose fingers grip the tube jackets.

Designations

	1	Wastewater heat exchanger
5	2	Housing
	3	Inlet
	4	Outlet
	5	Cleaning drain
	6	Safety overflow
10	7	Tube package
	8	Tube
	9	Fluid connection
	10	Support
	11	Retaining element
15	12	Lip
	13	Drive (of 14)
	14	Threaded spindle
	15	Threaded nut
	16	Finger
20	17	Lip band
	18	Longitudinal slot
	19	Recess
	20	Clamping strip
	21	Sliding bearing
25	22	Strut

Claims

1. Wastewater heat exchanger (1) comprising, in a housing (2) with inlet and outlet (3, 4) for the wastewater, a substantially cuboid package (7) of cylindrical tubes (8) arranged parallel to and below one another and through which a heat-absorbing fluid flows, and a cleaning device for the tube jackets, which is suspended above the tube package (7) slidably in the longitudinal direction of the tubes (8) and is provided with retaining elements (11) hanging down between the tubes (8) from a support (10), which carry elastic lips (12) that sweep over the tube jackets, characterized in that each lip (12) has a finger (16) engaging between two superimposed tubes (8) and is fixed in the retaining element (11) at an angle (α) of 5 to 30° to the longitudinal direction of the tubes (8), whereby adjacent fingers (16) cover at least half a tube jacket and the ends of the fingers (16) are curved in the longitudinal direction of the tubes (8), and that in each retaining element (11) two oppositely directed lips (12) are attached, which each sweep over laterally adjacent tubes (8), and that the support (10) of the retaining elements (11) is connected to a single guide extending in the longitudinal direction of the tubes (8).
2. Wastewater heat exchanger (1) according to claim 1, characterized in that several lips (12) are combined to form a common lip band (17), wherein the distance (a) between adjacent fingers (16) corresponds to 1.25 to 2.0 times the outer diameter of the tubes (8).
3. Wastewater heat exchanger (1) according to claim 1 or 2, characterized in that the length (l) of the fingers (16) corresponds to 2 to 3.25 times the outer diameter of the tubes (8).
4. Wastewater heat exchanger (1) according to one of claims 1 to 3, characterized in that the width (b) of the fingers (16) at the free finger end corresponds to 0.25 to 1.0 times the outer diameter of the tubes (8).
5. Wastewater heat exchanger (1) according to one of claims 1 to 4, characterized in that each finger (16) has a longitudinal slot (18) whose length corresponds to 0.5 to 3 times and whose width corresponds to 0.05 to 0.4 times the outer diameter of the tubes (8).

6. Wastewater heat exchanger (1) according to one of claims 1 to 5, characterized in that each lip (12) has at least one recess (19) at the base of the finger (16).
- 5 7. Wastewater heat exchanger (1) according to one of claims 1 to 6, characterized in that each retaining element (11) has clamping strips (20) between which the lips (12) pointing in opposite directions are received.
- 10 8. Wastewater heat exchanger (1) according to one of claims 1 to 7, characterized in that the guide of the support (10) of the retaining elements (11) consists of a stationary, rotatably mounted threaded spindle (14) which passes through a threaded nut (15) connected to the support (10).
- 15 9. Wastewater heat exchanger (1) according to claim 8, characterized in that sliding bearings (21) surrounding the threaded spindle (14) are provided on both sides of the threaded nut (15), preferably with a plastic sliding layer.
- 20 10. Wastewater heat exchanger (1) according to claim 9, characterized in that the longitudinal extent of each sliding bearing (21) corresponds to approximately 1/10 of the length of the tubes (8).
11. Wastewater heat exchanger (1) according to claim 9 or 10, characterized in that each sliding bearing (21) is supported on the support (10) by a strut (22).
- 25 12. Wastewater heat exchanger (1) according to claim 11, characterized in that the strut forms an angle of approximately 30° with the sliding bearing (21).