If one of the fluids that ~~are~~ is run through the system is, for example, seawater, the inlet filter will prevent contaminants (sand, loose shells etc.) from penetrating into the open elements.

When the end plates and the open elements are assembled to form the modular system for heat exchange between fluids according to the present invention, the open elements are arranged such that two adjacent open elements will carry the same fluid on sides facing each other.

The open element that is used in the modular system for heat exchange between fluids according to the present invention comprises a sheet material that is folded to form a plurality of slits, which slits constitute the fluid flow paths through the open element. When the sheet material is folded, it will however be "soft", and it is therefore preferable that it be stiffened.

This stiffening of the sheet material may be obtained, for example, in that the sheet material over at least a part of its length and width is configured with a plurality of stamped portions, which stamped portions are separated from each other by a non-stamped portion. The stamped portions will then form the walls of the slits in the folded sheet material, whilst the non-stamped portions form the fold in the sheet material, the sheet material then being folded about each of the non-stamped portions. The ends of the folded sheet material are further sealed, the sealed and folded sheet material being arranged in a frame.

That the sheet material is stamped should be understood as meaning that the surface of the sheet material is exposed to an external force which will change the shape (projection/depression) of the sheet material. The stamping may be in the form of continuous or discontinuous grooves or channels, dots or also a combination thereof.

It should however be understood that the stiffening of the folded sheet material can also be obtained in other ways, for example, by the provision of spacers between the slits of the folded sheet material.

The aforementioned stiffening means will result in the folded sheet material obtaining a desired stiffness over the whole or parts of the surface of the folded sheet material.

Although the slits in the folded sheet material are preferably configured as planar faces, it should be understood that they can also be configured as part circles, arcs or the like. A preferred embodiment is a structure consisting of forming one or more open areas that permit an efficient high-pressure washing in the slits.

The sheet material in the open element is constituted preferably of titanium or other suitable materials, the sheet material preferably having a thickness of 0.4mm-0.6mm. The distance between each slit in the folded sheet material will furthermore preferably be 2.5mm - 3.5mm.

The folded sheet material is further arranged in a frame, which frame is constituted of a top and a bottom frame. The top and the bottom frame of the frame will, by means of suitable fastening devices, for example, bolts or the like, be connected to each other so as to provide an open element. The top and the bottom of the ~~open element~~ frame will further comprise channels for inlet, outlet and fluid distribution.

A plurality of gaskets etc. may further be arranged between the top/bottom of the frame and the folded sheet material and/or between the top and bottom of the frame.

The frame may further be configured with a plurality of through holes, such that if the end seal or the gaskets begin to leak, the through holes in the frame will act as outlets for one or both fluids flowing through the open element, in such a way that they are not mixed.

In order to further stiffen the folded sheet material, a number of transverse elements can be placed across the width of the top and/or bottom frame.

To obtain a proper flow of the fluid across the open element, a plate may further be suitably connected to the transverse elements, such that the fluid is "forced" to flow through the slits in the open element.

Other advantages and characteristic features of the present invention will be seen clearly from the following detailed description, the appended figures and the following claims.

The present invention will now be described in more detail with reference to the following figures, wherein

Figures 1A-B show a modular system for heat exchange between fluids according to the present invention, which is in the process of being assembled and is fully assembled;

Figures 2A-B show an open element for heat exchange between fluids in the modular system shown in Figure 1;

Figures 3A-B show a sheet material in the open element for heat exchange between fluids, where the sheet material is shown prior to the folding and as fully folded;

and

Figure 4 shows the fully folded sheet material with sealed end faces.

Figure 1 shows a modular system 1 for heat exchange between fluids according to the present invention, where the modular system 1 is in the process of being assembled (or taken apart) in Figure 1A and where the modular system 1 is shown fully assembled in Figure 1B.

The modular system 1 for heat exchange between fluids according to the present invention is constituted of two end plates 2, between which end plates 2 are arranged four open elements 3 for heat exchange between fluids according to the illustrated embodiment. It should however be understood that a greater or smaller number of open elements 3 can be arranged between the end plates 2, this number depending on the

space available, desired capacity, back-up capacity and development potential. At least two elongate elements 4 are suitably 6 connected to one of the end plates 2, where at least one of the elongate elements 4 is connected in an area close to each of the end plate's 2 edges. The other end plate 2 is configured with at least one through hole, slot, cut-out 5 or the like in an area close to each of the end plate's edges 2, such that the at least one through hole, slot, cut-out 5 or the like in each edge of the one end plate 2 is used for passage of at least one of the elongate elements 4 in the other end plate 2, so as to assemble and connect the two end plates 2. The elongate element 4 will then be configured with a threaded portion (not shown) over a part of its length. The two end plates 2 will then be connected in that the at least one elongate element 4 in each of the edges of the one end plate 2 is passed through the at least one through hole, slot, cut-out 5 in the other end plate 2. A nut 6 will then be screwed onto each of the elongate elements 4, so as to assemble the end plates 2 and the open elements 3 arranged between the end plates 2.

An inlet filter 7 is in a suitable way, for example, with the aid of bolts or the like, connected to one of the end plates 2, which inlet filter 7 will reduce the danger of physical blockages in the modular system 1 for heat exchange between fluids, as a result of contaminants in one or both of the fluids to be heat exchanged.

One of the end plates 2 is further configured with an inlet and outlet 8, 9; 10, 11 for each of the fluids to be heat exchanged, where the inlet and outlet 8, 9 for a first fluid and the inlet and outlet 10, 11 for a second fluid are arranged on opposite edges of the end plate 2.

The inlet 8 for the first fluid will then be arranged diagonally opposite to the inlet 10 for the second fluid, and similarly the outlet 9 for the first fluid will be arranged diagonally opposite the outlet 11 for the second fluid. Thus, the fluids that are to be heat exchanged will flow in the opposite direction to each other when the modular system 1 for heat exchange between fluids is used, so as to achieve optimal heat transfer between the fluids.

How the pipes (not shown) for supply of the fluids to be heat exchanged are to be connected to the modular system 1 for heat exchange between fluids is not described in any detail here, as a person of skill in the art will know how this is to be done.

As disclosed above, the modular system 1 for heat exchange between fluids comprises a plurality of open elements 3, which open elements 3 will be described in more detail with reference to Figures 2 and 3. The open elements 3 are so arranged between the end plates 2 that two sides facing each other in two adjacent open elements 3 will carry the same fluid, which will mean, with reference to Figure 1, that a first and a second open element 3 in the sides facing each other will carry the first fluid, whilst sides in the second and a third open element 3 will then carry the second fluid.

Figures 2A-B show an open element 3 according to the present invention, where Figure 2A shows the different components of the open element 3, whilst Figure 2B shows the fully assembled open element 3. The main component of the open element 3 is constituted of a sheet material 13 which is folded to form a plurality of slits 14 (see also Figures 3 and 4). The sheet material 13, at each of its short ends, across the whole length of the short end, is sealed by means of an end seal 15. In addition, two permanent gaskets 16 are provided around the folded sheet material 13, each of the permanent gaskets 16 being configured so as to cover half of the end edges of the folded sheet material 13. When the folded sheet material 13 with the end seal 15 and the two permanent gaskets 16 are arranged in a frame 17, which is constituted of a bottom frame 17a and a top frame 17b, a tight connection will be formed between the edges of the folded sheet material 13 and the frame 17. However, as an extra safety measure, the frame 17 will be configured with a plurality of through holes (not shown) which extend into the outer side of the permanent gaskets and end seal 15, such that if the end seal 15 or the permanent gaskets 16 for some reason begin to leak, the though holes (not shown) in the frame 17 will act as outlets for one or both fluids that are passed through the open element 3. This means that any leakage from the open element 3 will not result in a mixing of the fluids that are to be heat exchanged.

The frame 17 will further comprise one or more service gaskets 18, these being arranged in the outer sides of the top and bottom frames 17a, 17b. In this way, when a plurality of open elements 3 are arranged in the modular system 1 for heat exchange between fluids, a sealed connection will be formed between the open elements 3.

The frame 17 will also comprise a carrying handle 19, such that the open element 3 can easily be handled during the assembly or dismantling of the modular system 1 for heat exchange between fluids.

In the frame 17, out towards each of the two ends of the frame 17, through holes 20, 21 are formed, where the through holes 20 constitute inlets for each of the fluids, whilst the through holes 21 constitute the outlets for each fluid. Each end of the frame 17 will thus be configured with one inlet and one outlet 20, 21. The inlet and outlet 20, 21 for one of the fluids will then be on one side of the open element 3, whilst the inlet and outlet 20, 21 for the other fluid will be arranged on the opposite side of the open element 3. The first fluid will then be passed into the open element 3 on one side, flow through the slits 14 in the folded sheet material 13 and then be passed out of the open element 3 on the same side. The other fluid will be passed into the open element 3 on an opposite side and end to the first fluid, flow over the folded sheet material 13 on the opposite side of the folded sheet material 13 and opposite the first fluid, whereafter the second fluid is passed out of the open element 3 at an opposite end to the inlet thereof. This arrangement will give optimum heat exchange between the two fluids.

In addition, one or more gaskets 181 will be arranged between the through holes 20, 21 when the frame 17 has been assembled.

The top and bottom frame 17a, 17b are configured with an open portion 22, such that when the folded sheet material 13 is arranged in the frame 17, most of the surface of the folded sheet material 13 will be exposed to a fluid that is to flow through the open element 3. Through this arrangement, where the frame 17 will only cover the edges of the folded sheet material 13 and the height of the sheet material 13, a large area of the folded sheet material 13 will be capable of being used efficiently for heat transfer between fluids.

In Figure 2B two transverse elements 182 are connected to the bottom frame 17b, which transverse elements 182 will extend over the whole width of the bottom frame 17b. These transverse elements 182 will stiffen the folded sheet material 13.

To obtain a proper flow of the fluid across the open element 3, a plate 183 may be arranged adjacent to the transverse elements 182. Such a plate 183 may then be arranged on one or both sides of the open element 3, see also Figure 2A. The plate 183 will then "force" the fluid to flow through the slits in the open element 3.

An open element 3 is thus provided where the effective heat transfer area exceeds the external area of the open element 3. Furthermore, an open element 3 will be provided where the slits 14 in the folded sheet material 13 are visible and accessible for cleaning, for example, by high pressure washing.

Figures 3A-B show the sheet material 13 that is used in the open element 3, and it is seen that the sheet material 13 is configured with a plurality of stamped portions 23 and non-stamped portions 24 arranged between them. The stamped portions 23 will, when the sheet material 13 is folded, constitute slits 14 in the open element 3, through which slits 14 a fluid is to flow. The non-stamped portions 24 will then form the "folding points" for the sheet material 13. See also Figure 4, where a fully folded sheet material 13 is shown. The stamping of the stamped portions 23 will provide necessary strength in the open element 3 to prevent the open element 3 from collapsing if the differential pressure across the open element 3 becomes too great, and will provide a turbulent flow in the fluids that are run through the open element 3.

The stamping here is shown as a "V-shape", but a person of skill in the art will understand that the stamping may also have other "patterns".

The stamping may, for example, be done in a press (not shown) or the like, where the sheet material 13 is fed through the press, a portion 23 is stamped, the press is lifted and a new length of the sheet material 13 is advanced in the press, whereafter the press stamps a new portion 23. This process is repeated until the desired number of stamped portions 23 has been obtained.

Amended set of claims

1. An open element (3) for heat exchange between fluids, comprising a sheet material (13) folded to form a plurality of slits (14), which slits (14) constitute the fluids' flow paths, wherein the sheet material (13) over at least a part of its width and length is by means of stiffening devices stiffened, and wherein the ends of the folded sheet material (13) are sealed by means of an end seal (15), characterised in that the open element (3) further comprises an open frame (17), the folded sheet material (13) ~~is~~ being arranged in ~~an~~ the open frame (17), each of the ends of the frame (17) being configured with two through holes forming inlets (20) and outlets (21) for each of the fluids, where the open frame (17) is constituted of a top and a bottom frame (17a, 17b) configured with an open portion (22), the open frame (17) thereby only covering the edges of the folded sheet material (13).

2. An element (3) according to claim 1, characterised in that the sheet material (13) is made of titanium.

3. An element (3) according to claim 1, characterised in that the element further comprises at least one gasket (16, 18, 181).

4. An element (3) according to claim 1, characterised in that the slit width to slit depth ratio is less than 0.15.

5. An element (3) according to any one of the preceding claims, characterised in that ~~the~~ walls are configured as planar faces, part circles, arcs or the like.

6. An element (3) according to claim 1, characterised in that the top and bottom frames (17a, 17b) are connected to each other by fastening devices.

7. An element according to claim 6, characterised in that the frame in at least one side is configured with at least one through hole, extending into the at least one gasket (16, 18).

8. A modular system (1) for heat exchange between fluids, comprising two end plates (2), wherein at least one end plate (2) is configured with inlets (8, 10) and outlets (9, 11) for fluids, characterised in that the modular system (1) comprises a plurality of open elements (3) according to claim 1, which open elements (3) are so arranged that two adjacent open elements (3) on sides facing each other carry the same fluid.

9. A modular system (1) according to claim 8, characterised in that at least one elongate element (4) is arranged in an area out towards the edge of each of the ends of one of the end plates (2), and where the other end plate (2) is configured with at least one through hole (5) in an area out towards the edge of each of the ends of the end plate (2), so as to be able to assemble the end plates (2).

10. A modular system according to one of claims 8-9, characterised in that the modular system (1) comprises at least one filter (7).

PATENT CLAIMS

1. An open element for heat exchange between fluids, comprising a sheet material folded to form a plurality of slits, which slits constitute the fluids' flow paths, wherein the sheet material over at least a part of its width and length is by means of stiffening devices stiffened, wherein the ends of the folded sheet material are sealed by means of an end seal, and wherein the open element further comprises an open frame, the folded sheet material being arranged in the open frame, each of the ends of the frame being configured with two through holes forming inlets and outlets for each of the fluids, where the open frame is constituted of a top and a bottom frame configured with an open portion, the open frame thereby only covering the edges of the folded sheet material.

2. An element according to claim 1, wherein the sheet material is made of titanium.

3. An element according to claim 1, wherein the element further comprises at least one gasket.

4. An element according to claim 1, wherein the slit width to slit depth ratio is less than 0.15.

5. An element according to any one of the preceding claims, wherein walls of the slits in the folded sheet material are configured as planar faces, part circles, arcs or the like.

6. An element according to claim 1, wherein the top and bottom frames are connected to each other by fastening devices.

7. An element according to claim 3, wherein the frame in at least one side is configured with at least one through hole, extending into the at least one gasket.

8. A modular system for heat exchange between fluids, comprising two end plates wherein at least one end plate is configured with inlets and outlets for fluids, wherein the modular system comprises a plurality of open elements according to any one of claims 1-7, which open elements are so arranged that two adjacent open elements on sides facing each other carry the same fluid.

9. A modular system according to claim 8, wherein at least one elongate element is arranged in an area out towards the edge of each of the ends of one of the end plates, and where the other end plate is configured with at least one through hole in an area out towards the edge of each of the ends of the end plate, so as to be able to assemble the end plates.

10. A modular system according to any one of claims 8-9, wherein the modular system comprises at least one filter.