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(71) Applicant: **Danfoss A/S**
6430 Nordborg (DK)

(72) Inventor: **Persson, Lars**
550014 Guizhou (CN)

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(54) **Heat exchanger, heat exchanger plate, and method for producing a heat exchanger**

(57) A heat exchanger is provided comprising a stack of a plurality of pairs of heat exchanger plates (1,a, 1b, 1c) formed of sheet metal having a three-dimensional structured pattern, a first flow path being defined within the plurality of pairs and a second flow path being defined between said pairs, each plate having at least one through-opening.

It is intended to have a solid connection between adjacent heat exchanger plates.

To this end at least one auxiliary opening is provided in said plate (1a, 1b, 1c), said auxiliary opening having a raised edge forming a flange (11, 13, 14), said flange (11, 13, 14) being inserted into a corresponding auxiliary opening of a neighbouring plate.

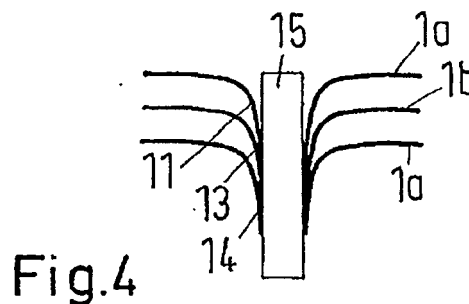


Fig.4

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Description

[0001] The invention relates to a heat exchanger comprising a stack of a plurality of pairs of heat exchanger plates formed of sheet metal having a three-dimensional structured pattern, a first flow path being defined within the plurality of pairs and a second flow path being defined between said pairs, each plate having at least one through-opening.

[0002] Furthermore, the invention relates to a heat exchanger plate formed of sheet metal having a three-dimensional structured pattern.

[0003] The invention relates as well to a method for producing a heat exchanger forming a stack of heat exchanger plates made of sheet metal having a three-dimensional structured pattern.

[0004] A heat exchanger of the kind mentioned above is known from US 2007/0261829 A1. The heat exchanger plates of this heat exchanger have a three-dimensional structured pattern comprising bulges and hollows. The bulges and hollows are placed against respective hollows and bulges of an adjacent heat exchanger plate to form the flow path on the primary and on the secondary side of the heat exchanger.

[0005] The particular form of the pattern of the heat exchanger plate can be changed. As an alternative, heat exchanger plates comprising a kind of herringbone pattern can be used.

[0006] A heat exchanger is used to transfer heat from a fluid on the primary side, i.e. a fluid flowing through the first flow path, to a fluid on the secondary side, i.e. to a fluid passing through the second flow path. In many cases at least one of these fluids has an elevated pressure. The connection between two neighbouring plates must be strong enough to withstand this pressure. This is usually no problem in an area where there are enough bulges and hollows. However, in some areas of the plates an additional connection is necessary.

[0007] The task underlying the invention is to have a solid connection between adjacent heat exchanger plates.

[0008] This task is solved in that at least one auxiliary opening is provided in said plate, said auxiliary opening having a raised edge forming a flange, said flange being inserted into a corresponding auxiliary opening of a neighbouring plate.

[0009] The flanges are integral with the plate. They can easily be formed just by pressing the sheet metal in the area of the auxiliary opening into the flange. This pressing can be made simultaneously with the forming of the three-dimensional structured pattern. The term "sheet metal" covers all materials having a good thermal conductivity and can be formed in a press or die. It is also possible to use plastic material as sheet metal.

[0010] In a preferred embodiment the flange of an auxiliary opening of one plate is connected to the flange of an auxiliary opening of a neighbouring plate. This connection can be made by welding or brazing. When the

flanges are connected in this kind two neighbouring plates are not only secured against shearing forces but also against forces exerted by an elevated pressure. Such a pressure usually tends to increase the distance between two neighbouring plates. Since the flanges can withstand tensile forces it can be made sure that the distance is not increased.

[0011] Preferably the flanges of a plurality of auxiliary openings form a cylinder and a stabilisation element is inserted into said cylinder. In this way it is possible to connect a plurality of plates or even all plates of the stack of heat exchanger plates. The stabilisation element prevents that a pressure acting between two adjacent plates compresses the flanges radially which could lead to a weakening of the connection between two neighbouring plates.

[0012] Preferably at least the outermost flanges are connected to said stabilisation element. However, all flanges can be connected to said stabilisation element as well. The stabilisation element can withstand higher tensile forces so that the stack of plates can withstand higher pressures inside the stack of plates.

[0013] Preferably at least one auxiliary opening is positioned in the vicinity of said through-opening. In the vicinity of said through-opening there is normally no sufficient connection between two neighbouring plates. The flange of the auxiliary opening serves for a connection between two adjacent or neighbouring plates.

[0014] Preferably a transition zone between said flange and said plate is rounded and the flange of a plate contacts the flange of a neighbouring plate beyond the transition zone. This means that a connection between two adjacent flanges is made where the flanges have already a cylindrical form. This makes the connection simple. In the contact area or overlapping area the two flanges are parallel to each other so that a reliable connection can be achieved. In the contact area the two flanges can be parallel to each other.

[0015] Preferably an endplate is provided having a bulge adapted to receive flanges of at least a heat exchanger plate next to said endplate. In a system having a stack of heat exchanger plates with raised edges forming flanges there could arise a problem at the bottom plate, where there is no neighbouring plate. One solution is to provide said endplate with a bulge which is adapted to receive the flange of at least a heat exchanger plate next to said endplate. In this case the heat exchanger plate next to the endplate can have the same shape as all the other heat exchanger plates of the heat exchanger. Preferably the bulge is adapted to receive the flange not only of the heat exchanger plate next to said endplate but also the flange of at least the second heat exchanger plate counted from the endplate.

[0016] Preferably said bulge has a depth, said depth being larger than a height of said flange perpendicular to said heat exchanger plate next to said endplate. In this case the tongues can remain in their upright state, i.e. it is not necessary to deform the flange. In any case, the

flange or flanges can be connected to the wall of the bulge.

[0017] In an alternative embodiment a flange of a heat exchanger plate next to an endplate is, at least at its tip, deformed parallel to said endplate. These flange is deformed at least twice comprising a first section almost perpendicular to the plane of the heat exchanger plate and further comprising a second section parallel to the plane of the endplate.

[0018] In this case it is preferred that the flanges of at least two heat exchanger plates next to said endplate form, at least at their tips, a layered structure on an internal surface of said endplate. This layered structure can easily be connected to said endplate.

[0019] The task is solved with a heat exchanger plate of the kind mentioned above in that an auxiliary opening is provided having a raised edge forming an upstanding flange.

[0020] As mentioned above this flange is made integral with the heat exchanger plate. It can easily be formed by pressing the sheet metal out of the area of the auxiliary opening to form a raised edge of the auxiliary opening. This raised edge forms a flange which can be used to connect two adjacent heat exchanger plates to each other. Preferably a transition zone between said flange and said plate is rounded. A rounded transition zone prevents weakening of the sheet metal in the area around the auxiliary opening.

[0021] A task is solved by a method for producing a heat exchanger as mentioned above in that an auxiliary opening having a raised edge is formed in said plates, said raised edge forming a flange, said flange being inserted in a corresponding auxiliary opening of a neighbouring plate.

[0022] The flanges can withstand shear forces between neighbouring or adjacent plates. They produce an increased stability of the stack of plates.

[0023] In a preferred embodiment said flanges are connected to each other. The flanges are used to prevent that neighbouring plates increase their distance when there is an elevated pressure between the true plates. In this case the flanges are subjected to tensile forces. However, since the flanges are made integral with the heat exchanger plate they are stable enough to withstand these tensile forces generated by the pressure between two plates.

[0024] Preferably a stabilisation element is inserted through a plurality of auxiliary openings. This stabilisation element supports the flanges from the inside so that the elevated pressure cannot compress the flanges in radial direction (related to the auxiliary opening). Such a radial compression could weaken the connection between flanges of adjacent plates.

[0025] Preferably said stabilisation element is connected at least to the flanges of the outermost plates of the stack of heat exchanger plates. When there is an elevated pressure inside the stack of heat exchanger plates this pressure cannot "blow up" the stack of heat exchang-

er plates since the outermost plates are held together by means of the stabilisation element. In a preferred embodiment all flanges are connected to the stabilisation element so that even inside the stack of heat exchanger plates the blowing up due to an elevated pressure can be prevented.

[0026] A preferred example of the invention will now be described in more detail with reference to the drawing, wherein:

Fig. 1 is a plan view of a heat exchanger plate,

Fig. 2 is an enlarged view of the upper right corner of the heat exchanger plate of Fig. 1,

Fig. 3 is a perspective view of an auxiliary opening,

Fig. 4 is a view of an arrangement of a plurality of heat exchanger plates in the region of an auxiliary opening,

Fig. 5 shows an example of connection of flanges with a bottom plate, and

Fig. 6 shows an alternative to the embodiment of Fig. 5.

[0027] Fig. 1 shows a heat exchanger plate 1a as it is shown in US 2007/0261829 A1. This plate 1a comprises bulges 2 which are raised by a given height over the plane of the heat exchanger plate 1a. Furthermore, the heat exchanger plate 1a comprises hollows 3 which are sunk to a given depth in this heat exchanger plate 1a. The bulges 2 are symbolized by white circles while the hollows 3 are symbolized by circles with a cross. As it is described in US 2007/0261829 A1 two such heat exchanger plates 1a form a pair of plates, in which one heat exchanger plate 1a is rotated about 180° about its longer edge 4. A plurality of such pairs is stacked one above the other. A first flow path is formed within the pairs and a second flow path is formed between these pairs.

[0028] The heat exchanger plate 1a comprises four through-openings 5-8. These through-openings 5-8 are used to form channels or connections. For example, the through-openings 5, 7 forms a supply and a return for the first flow path and the through-openings 6, 8 form a supply and a return for the second fluid path.

[0029] The heat exchanger plate 1a is formed of a sheet metal. The term "sheet metal" defines a material having a good thermal conductivity. Furthermore, the material can be formed in a press or die. The bulges 2 and the hollows 3 form a three-dimensional structured profile. This profile is produced in a press or die.

[0030] When a plurality of heat exchanger plates 1a, 1b, 1c (Fig. 4) is stacked one above the other to form a stack the bulges 2 of a plate 1b is connected to the bulges 2 of the heat exchanger plate 1a which is turned about the edge 4 by 180°. The hollows 3 of plate 1b are con-

nected to the hollows 3 of heat exchanger plate 1c which is also turned about the edge 4 by 180°. These connections can be made by welding. These connections are stable enough to withstand the pressure of a fluid between two plates 1a, 1b or 1b, 1c respectively.

[0031] However, in the vicinity of the through-openings 5-8 the connection between two adjacent plates is not sufficient. In for example a heat exchanger as disclosed in US 2007/0261829 A1 two adjacent plates are welded with the top surfaces of the bulges 2 of one plate welded to the top surfaces of the hollows 3 of a adjacent plate. This gives a good connection of the two plates due to the density of the bulges 2 and hollows 3, meaning the number of these per square area of the plates.

[0032] In the opening areas 5-8 however, it is common, both in heat exchangers of the kind as disclosed in US2007/0261829 or the more common herringbone pattern plate heat exchangers, to encircle the openings 5-8 with bulges and hollows to be welded together, the density of these being limited by the openings 5-8 themselves and their sizes of being limited in that there needs to be fluid access into the spaces between the plates. Therefore it is a problem these areas often are the area of the highest pressures within the heat exchanger.

[0033] As can be seen in Fig. 2 a plurality of auxiliary openings 9 is provided and circling the through-opening 5. Similar auxiliary openings 9 can be provided around the other through-openings 6-8.

[0034] The auxiliary openings 9 can be formed in the same press or die which is used to form the bulges 2 and hollows 3. The auxiliary opening 9 has a raised edge 10 forming a flange 11, i.e. a wall surrounding the auxiliary opening 9. This flange 11 can be made of the sheet metal which in the past had to be removed in order to form the auxiliary opening. The flange 11 stands almost upright with respect to the plane 12 of the heat exchanger plate 1a.

[0035] Fig. 4 shows the situation coming out, when several plates 1a, 1b, 1c are stacked. The flange 11 of heat exchanger plate 1a is inserted into the auxiliary opening 9 of the next or adjacent heat exchanger plate 1b contacting the flange 13 of the corresponding auxiliary opening 9 of heat exchanger plate 1b. The flange 13 of heat exchanger plate 1b is inserted into auxiliary opening 9 of heat exchanger plate 1c contacting the corresponding flange 14 of its neighbouring heat exchanger plate 1c. The flanges 11, 13, 14 can be welded together forming a sort of "cylinder" reaching through the auxiliary openings.

[0036] A bolt 15 (or another stabilisation element) is inserted into the cylinder and may optionally be fixed in the cylinder. In some cases it is sufficient that the bolt 15 is connected to the flanges 11, 14 of the outermost heat exchanger plates 1a, 1c. In most cases, however, it is preferred that the bolt 15 is connected to all flanges 11, 13, 14.

[0037] As can be seen in Fig. 4 a transition zone between the flange 11, 13, 14 and the plates 1a, 1b, 1c is

rounded and the flange 11, 13 of a plate 1a, 1b contacts the flange 13, 14 of a neighbouring or adjacent plate 1b, 1c beyond the transition zone. This has the effect that the flanges contact each other in a cylindrical area.

[0038] Similar auxiliary openings may be distributed over the heat exchanger plate to enhance strength.

[0039] As described above, the auxiliary openings 9 can be formed in the same tool as the bulges 2 and hollows 3. However, it is clear that the auxiliary openings 9 together with the flanges 11, 13, 14 can be formed in a separate tool.

[0040] In the present example the pattern is formed by bulges 2 and hollows 3. However, it is clear that other forms of pattern can be used, e.g. a herringbone pattern.

[0041] Having a system with raised edges forming flanges 10 around the through-openings 5-8 gives a problem at an endplate, for example a bottom plate 18 where there is no neighbouring plate.

[0042] Fig. 5 shows a first solution to this problem, where the bottom plate 18 has a bulge 19 adapted to receive the flange 10 of a heat exchanger plate 1d next to the endplate 18. It can be seen that the bulge 19 has a depth which is larger than a height of the flange 10 perpendicular to the plane of the heat exchanger plate 1d next to the endplate 18. In this case it is possible that the flange 10 is fully inserted into the bulge 19 without a necessity for deforming the flange 10.

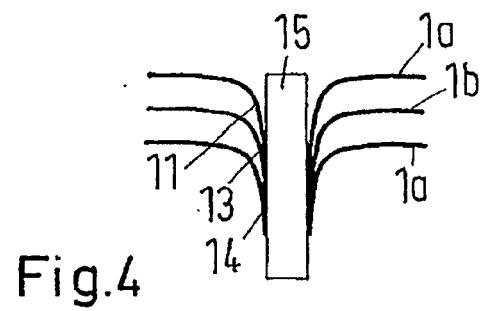
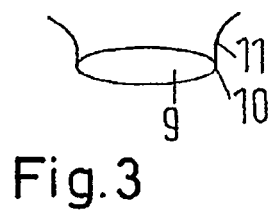
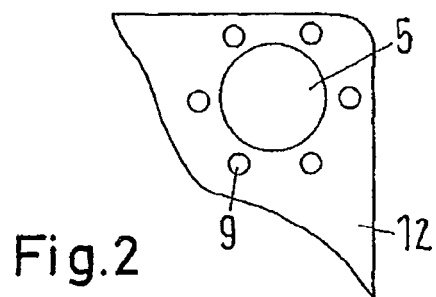
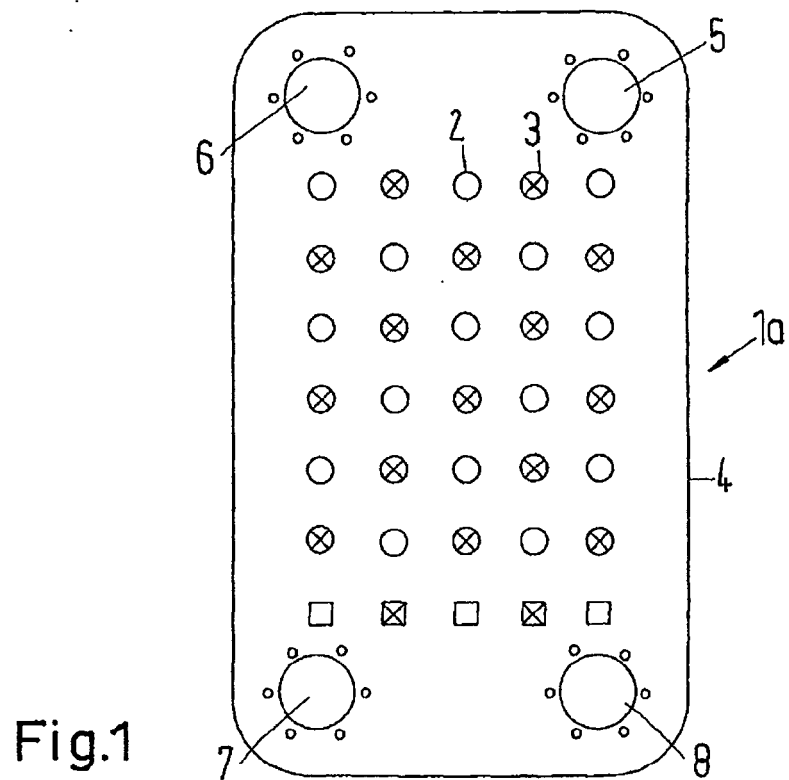
[0043] The bulge 19 not only receives the flange 10 of the heat exchanger plate 1d next to the endplate 18, but also the flange of the second heat exchanger plate 1e counted from the endplate 18. The flanges of these two heat exchanger plates 1d, 1e can be connected to the internal wall of the bulge 19. However, it is possible to insert even more flanges into the bulge 19, i.e. the flanges of more heat exchanger plates 1d, 1e

[0044] Another possibility is shown in Fig. 7. In this case an endplate 20 is used having a plane internal surface 21. The tongues 10 of the heat exchanger plates 1d, 1e next to the endplate 20 are further bent forming sections 22 running parallel to the internal surface 21 of said endplate 20. These tongues form a layered structure on the internal surface 21 of said endplate 20.

45 Claims

1. A heat exchanger comprising a stack of a plurality of pairs of heat exchanger plates (1a, 1b, 1c) formed of sheet metal having a three-dimensional structured pattern, a first flow path being defined within the plurality of pairs and a second flow path being defined between said pairs, each plate having at least one through-opening (5-8), **characterized in that** at least one auxiliary opening (9) is provided in said plate (1a, 1b, 1c), said auxiliary opening (9) having a raised edge (10) forming a flange (11, 13, 14), said flange (11, 13, 14) being inserted in a corresponding auxiliary opening (9) of a neighbouring plate (1b, 1c).

2. The heat exchanger according to claim 1, **characterized in that** the flange (11, 13) of an auxiliary opening (9) of one plate (1a, 1b) is connected to the flange (13, 14) of an auxiliary opening (9) of a neighbouring plate (1b, 1c). 5
3. The heat exchanger according to claim 1 or 2, **characterized in that** the flanges (11, 13, 14) of a plurality of auxiliary openings (9) form a cylinder and a stabilisation element (15) is inserted into said cylinder. 10
4. The heat exchanger according to claim 3, **characterized in that** at least the outermost flanges (11, 14) are connected to said stabilisation element (15). 15
5. The heat exchanger according to any of claim 1 to 4, **characterized in that** at least one auxiliary opening (9) is positioned in the vicinity of said through-opening (5-8). 20
6. The heat exchanger according to any of claims 1 to 5, **characterized in that** a transition zone between said flange (11, 13, 14) and said plate (1a, 1b, 1c) is rounded and the flange (11, 13) of a plate (1a, 1b) contacts the flange (13, 14) of a neighbouring plate (1b, 1c) beyond the transition zone. 25
7. The heat exchanger according to any of claims 1 to 6, **characterized in that** an endplate (18) is provided having a bulge (19) adapted to receive flange (10) of at least a heat exchanger plate (1d) next to said endplate (18). 30
8. The heat exchanger according to claim 7, **characterized in that** said bulge (19) has a depth, said depth being larger than a height of said flanges (10) perpendicular to said heat exchanger plate (1d) next to said endplate (18). 35
9. The heat exchanger according to any of claims 1 to 6, **characterized in that** a flange (10) of a heat exchanger plate (1d) next to an endplate (20) is, at least at its tip, deformed parallel to said endplate (20). 40
10. The heat exchanger according to claim 9, **characterized in that** the flange (10) of at least two heat exchanger plates (1d, 1e) next to said endplate (20) form, at least at their tips, a layered structure on an internal surface (21) of said endplate (20). 45
11. A heat exchanger plate (1a) formed of a sheet metal having a three-dimensional structured pattern (2, 3), **characterized in that** an auxiliary opening (9) is provided having a raised edge (10) forming an upstanding flange. 50
12. The heat exchanger plate according to claim 11, **characterized in that** a transition zone between said flange (11) and said plate (1a) is rounded. 55
13. A method for producing a heat exchanger forming a stack of heat exchanger plates (1a, 1b, 1c) made of sheet metal having a three-dimensional structured pattern (2, 3), **characterized in that** an auxiliary opening (9) having a raised edge (10) is formed in each of said plates, said raised edge forming a flange, said flange being inserted in a corresponding auxiliary opening (9) of a neighbouring plate (1b).
14. The method according to claim (13), **characterized in that** said flanges (11, 13, 14) are connected to each other.
15. The method according to claim 13 or 14, **characterized in that** a stabilisation element (15) is inserted through a plurality of auxiliary openings (9).
16. The method according to claim 15, **characterized in that** said stabilisation element (15) is connected at least to the flanges (11, 13) of the outermost plates (1a, 1c) of the stack of heat exchanger plates.



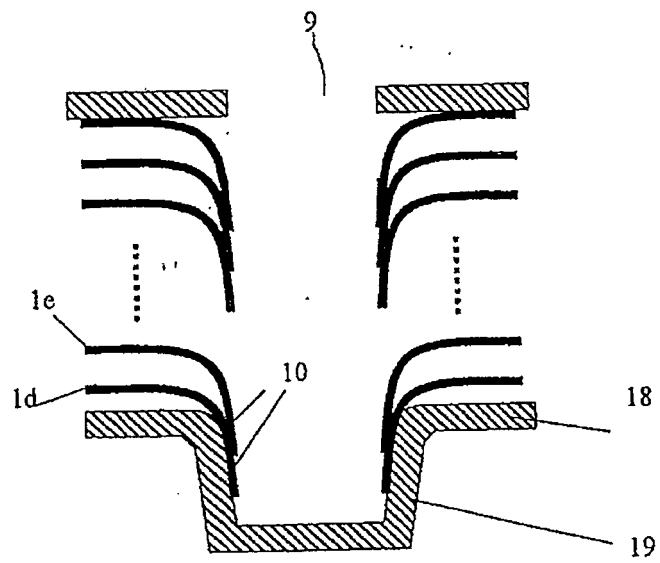


Fig. 5

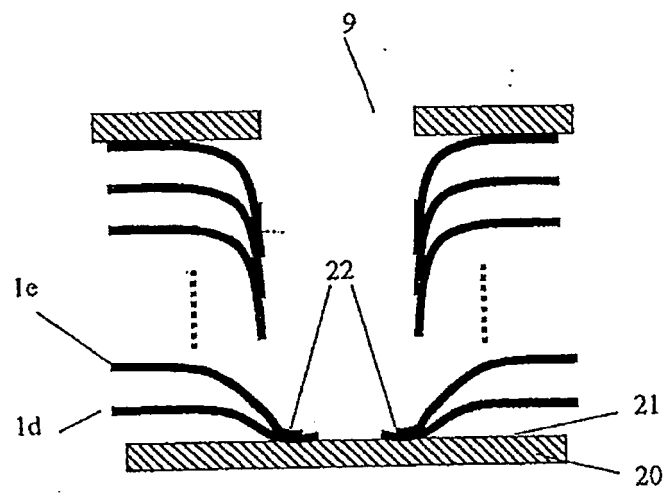


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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