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(54) A METHOD OF MANUFACTURING A HEAT EXCHANGER

VERFAHREN ZUR HERSTELLUNG EINES WÄRMETAUSCHERS

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Description

Technical field

[0001] The present invention generally relates to a method of manufacturing a plate heat exchanger. It further relates to a plate heat exchanger manufactured using said method.

Background of the invention

[0002] Heat exchanging equipment is widely used for changing or maintaining the temperatures of machinery, buildings, components and the like. Basically, such equipment operate by conveying heat energy from one place to another, either by removing heat from an object to be cooled down or by transferring heat to an object to be warmed up.

[0003] The basic principle of most heat exchangers is to transfer heat between two or more fluids. The heat transfer takes place mainly due to the temperature gradient, as the respective fluids are moving towards thermal equilibrium. Secondly, heat can move faster to and from the contact surface if the heat convection in the fluid is increased. A way to increase the convection within fluids is to design the heat exchanger so that the fluid flows are turbulent, as the convection is highly dependent on the turbulence level of the respective fluid.

[0004] The manufacturing method needs to ensure that the heat exchangers possess a certain strength to be able to sustain the pressure from the fluid flows. The higher the pressure a heat exchanger can sustain, the more versatile it is in application. Thus, it is advantageous to manufacture the strongest possible heat exchangers. Furthermore, for some heat exchanger applications it is relevant to prevent leakage of dangerous process fluids such as refrigerants to the surroundings, which could result in hazardous contamination and system malfunctions.

[0005] Furthermore, heat exchangers should be manufactured from a material that enables a high degree of heat transfer. Further on, this material needs to be resistant to chemical reactions with the fluids it is to convey.

[0006] Typically, turbulent flow increases the pressure loss in the heat exchanger, which increases the amount of energy needed to circulate the fluid. Hence, the heat exchanger design must balance the need for turbulence with the need to keep the pressure loss low. In the current art this balance is sought by rather complex designs of heat exchangers. The complex design needed to give the heat exchangers the required set of properties imposes undesirable constraints to the manufacturing method.

[0007] A plate heat exchanger is a frequently used type of heat exchanger that uses profiled plates in order to transfer heat between two fluids. The plate heat exchanger is normally manufactured by stacking a plurality of profiled heat exchanger plates, coupling them suitably and subsequently applying sealant in order to avoid that the two media mix and hence decrease the efficiency of the heat exchanger. Coupling and sealing of the individual plates may by way of example be done by gluing or welding. Alternatively, the coupling of the individual plates may by done by punching suitable flaps on the plates. WO 2007071253 discloses such an arrangement where plates are provided with foldable flaps.

[0008] Above-mentioned methods of plate coupling as well as use of different sealants render heat exchanger manufacturing difficult.

[0009] Furthermore, said methods entail use of fairly thick plates. This is required since the plates need to sustain the strain caused by said methods of plate coupling. Consequently, the material consumption increases. This contributes to increase the costs of manufacturing the heat exchanger.

[0010] Document EP 0167 993, representing the closet prior art to the subject-matter of claims 1 and 11, discloses a method of manufacturing a plate heat exchanger according to the preamble of claim 1 and a plate heat exchanger according to the preamble of claim 11.

Summary of the invention

[0011] In view of the above, an objective of the present invention is to provide an improved method of manufacturing a plate heat exchanger.

[0012] Yet another objective of the present invention is to reduce the material consumption used in connection with the manufacture of the plate heat exchanger.

[0013] Another objective is to provide the plate heat exchanger manufactured using said method.

[0014] In view of at least these objects, the invention relates to a method of manufacturing a plate heat exchanger, said method comprising the steps of providing a first heat exchanger plate, covering the first heat exchanger plate with at least a second heat exchanger plate, folding portions of the two heat exchanger plates together along at least a section of at least one border associated with said plates to form a fold, applying a sealant said sealant being applied to at least a part of a lateral surface constituted by said heat exchanger plates.

[0015] By achieving first fold along at least the section of at least one border associated with said plates, a tight joint between the adjacent plates may be obtained. Border should here be construed as the extreme peripheral portion of the heat exchanger plate. The joint made in this manner constitutes a physical obstacle for the fluid that flows between said plates. This may contribute significantly, in conjunction with the inherent design of the heat exchanger, to isolate the desired parts of the heat exchanger from the surroundings as said joints may be part of the lateral surface of the heat exchanger. Said lateral surface should be construed as extending circumferentially and being substantially perpendicular to the heat exchanger plates. Once said joints form lateral walls of the heat exchanger an increased structural stability of

said heat exchanger may be achieved. Furthermore, a simplified joining of the plates may be achieved since use of additional tools and means in order to join the adjacent plates is made superfluous. Subsequently, a sealant may be applied externally to at least a part of the said lateral surface in order to provide a tight seal between the desired parts of the heat exchanger and the surroundings. This sealant may also provide additional mechanical stability to the heat exchanger.

[0016] Said method may further comprise that at least said first and second heat exchanger plate are being part of an uninterrupted strip of material. In this way, the stacking of the plates is simplified. Further on, the risk of a leak on the lateral surface of the heat exchanger may be greatly reduced due to the inherent properties of the manufacturing method. As an advantage, a more robust heat exchanger may be obtained.

[0017] Said method may further comprise the step of providing at least a part of an outer surface of the at least one fold with indentations. In this way, recesses are created on the outer surface of the fold. These recesses may contribute to prevent the unfolding of the said fold. The unfolding may occur due to the elevated internal pressure of the fluids in the heat exchanger. As an advantage, a more robust heat exchanger may be obtained.

[0018] Said method may further comprise the step of providing at least one surface constituted by said heat exchanger plates with an end plate. End plates may be positioned on any part of the lateral surface or on the top respectively bottom surface of the heat exchanger. As an advantage, the heat exchanger may acquire increased mechanical stability as well as protection from undesirable external influences.

[0019] Said folding may be carried out by means of at least one roll. In this way the portions of the two plates may be jointly folded. Thus, the folding may be achieved in a controlled and precise manner.

[0020] Said first fold may be essentially cylinder-shaped with the diameter that is preferably between 1,5 mm and 2,5 mm, more preferred between 1,7 and 2,3 mm and most preferred between 1,9 and 2,1 mm. In this way, since said fold may be positioned at the respective fluids inlet into the heat exchanger, the fold may be used to regulate the flow of the fluid into the heat exchanger. As an advantage, by suitably sizing the fold, an increased efficiency of the heat exchanger may be obtained. Furthermore, by suitably shaping and positioning the fold, noise levels generated by the operating heat exchanger may be reduced.

[0021] Said method may further comprise the step of providing at least one heat exchanger plate with a hydrophobic coating. Hereby, an improved corrosion protection of the heat exchanger may be obtained. As an advantage, the useful life of the heat exchanger may be prolonged. Furthermore, the heat exchanger may require reduced maintenance.

[0022] Said method may further comprise the step of bringing in contact a portion of the first heat exchanger plate with a portion of the second heat exchanger plate along at least a part of at least a first border whereby said step may be carried out by means of clamping means. In this way, it may be achieved that the peripheral portions of the two plates abut eachother prior to folding. Appropriate folding is hereby facilitated.

[0023] Said method may further comprise the step of arranging a first border of the first heat exchanger plate with an offset to a first border of the second heat exchanger plate. In this way, at one plate end, the lower positioned plate extends beyond the plate that is positioned on top of it. Consequently, the first border of the first and the second plate are not aligned. As an advantage, appropriate folding is facilitated.

[0024] Said offset may preferably be between 0,5 and 1,5 mm, more preferred between 0,7 and 1,3 mm and most preferred between 0,8 and 1,2 mm.

[0025] According to a second aspect, the invention relates to a plate heat exchanger comprising at least three stacked heat exchanger plates, wherein two adjacent plates are interconnected along at least a part of at least one border associated with said plates by a fold, said fold being constituted of peripheral portions of said adjacent plates, and wherein a sealant is applied to at least a part of a lateral surface constituted by said at least three stacked heat exchanger plates.

[0026] This allows, as has been discussed above in view of the method of manufacturing a plate heat exchanger, that a tight joint between two adjacent plates may be obtained. Border should here be construed as the extreme peripheral portion of the heat exchanger plate. The joint made in this manner and positioned in the peripheral portion of the heat exchanger plates constitutes a physical obstacle for the fluid that flows between said plates. This may contribute significantly, in conjunction with the inherent design of the heat exchanger, to isolate the desired parts of the heat exchanger from the surroundings as said joints may be part of the lateral surface of the heat exchanger. Said lateral surface should be construed as extending circumferentially and being substantially perpendicular to the heat exchanger plates. Once said joints form lateral walls of the heat exchanger an increased structural stability of said heat exchanger may be achieved. Furthermore, a simplified joining of the plates may be achieved since use of additional tools and means in order to join the adjacent plates is made superfluous. Subsequently, a sealant may be applied externally to at least a part of the said lateral surface in order to provide a tight seal between the desired parts of the heat exchanger and the surroundings. This sealant may also provide additional mechanical stability to the heat exchanger.

[0027] The thickness of the heat exchanger plate may preferably be less than 110 microns, more preferred less than 100 microns and most preferred less than 95 microns. Standard plate joining techniques such as welding would typically require relatively thick plates. By introducing the inventive plate heat exchanger, the joining of the

plates may be performed by using a portion of the respective plate. This allows for use of thinner heat exchanger plates. As an advantage, significant reductions in material consumption may be achieved. Furthermore, the plates made in a thinner material allow for a greater amount of fluid to enter the heat exchanger. This, in turn, may reduce the pressure drop in the heat exchanger. As an alternative, due to reduced plate thickness, additional plates may be incorporated while maintaining the external dimensions of the heat exchanger. In this way, an increased surface area suitable for heat exchange may be achieved while pressure drop in the heat exchanger remains constant.

[0028] Said plate heat exchanger may be a countercurrent plate heat exchanger. Due to its inherent properties said heat exchanger may be able to maintain a nearly constant gradient between two substantially equal fluid flows. In this way, significant temperature changes of the respective fluid may be achieved. This may be useful when said plate heat exchanger is used for e.g. air conditioning appliances.

[0029] Said plate heat exchanger may have the fold that is essentially cylinder-shaped and the ratio between the diameter of the said fold and the vertical distance between the adjacent plates is preferably less than 1.5, more preferred less then 1.25, and most preferred less then 1.1. By adequately sizing the fold with reference to the distance between adjacent plates, the occurrence of undesirable turbulence in the plate heat exchanger may be significantly reduced. As an advantage, the efficiency of the plate heat exchanger may be increased.

[0030] Other objectives, features and advantages of the present invention will appear from the following detailed disclosure, from the attached claims as well as from the drawings.

[0031] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the [element, device, component, means, step, etc]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

Brief description of the drawings

[0032] The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments of the present invention, with reference to the appended drawings, where the same reference numerals will be used for similar elements, wherein:

Fig 1 is a schematic drawing of a plate heat exchanger according to one embodiment of the present invention;

Fig 2a-2d illustrate different steps of a method of manufacturing a plate heat exchanger according to one embodiment of the present invention;

Fig 3a-3d illustrate, by means of a cross-sectional view, different steps of a plate folding process according to one embodiment of the present invention;

Fig 4a is a cross-sectional view of peripheral portions of the adjacent plates comprising a fold;

Fig 4b is a front view of the fold shown in Fig 4a;

Fig 5 is a perspective view of an air-air countercurrent heat exchanger according to one embodiment of the present invention;

Detailed description of preferred embodiments

[0033] Fig 1 is a schematic drawing of a plate heat exchanger 2 according to one embodiment of the present invention.

[0034] The schematically shown plate heat exchanger 2 is of the countercurrent type. Accordingly, the two fluids move in opposite directions. The plate heat exchanger 2 comprises a stack of mutually spaced plates. Number of plates may vary from around 50 to several hundreds, depending on the application. According to one embodiment of the present invention, a hot fluid inlet 6 and a hot fluid outlet 8 (indicated by arrow) are positioned adjacent one another at the hot end 10 of the heat exchanger 2. Analoguosly, a cold fluid inlet 12 and a cold fluid outlet 14 (indicated by arrow) are in turn positioned adjacent one another at the cold end 16 of the heat exchanger 2.

[0035] The transfer of heat between the two fluids takes place via plates. In order to maximize the heat transfer between two fluids the plates are profiled since this contributes to an increased indirect contact surface between the fluids. Heat exchanger becomes more efficient if this contact surface is maximised.

[0036] Plate heat exchangers are used for heat exchange between fluids. From the respective inlet, the flow of the two fluids is distributed into a plurality of channels (not shown), wherein a channel adapted for transport of one fluid is normally sandwiched between two channels that are conveying the other fluid. In the countercurrent heat exchanger comprising the hot end 10 and the cold end 16 and being schematically shown in fig 1 the incoming hot fluid exchanges heat directly with already heated incoming cold fluid. This is done in order to additionaly increase the outlet temperature of the incoming cold fluid before said fluid exits the heat exchanger at the hot end. Obviously, the temperature of the incoming hot fluid is reduced in this process and said incoming hot fluid that has been cooled down subsequently exits the heat exchanger at the cold end 16. Analoguosly, the incoming cold fluid exchanges heat directly with already cooled down incoming hot fluid. Ideally, the process of heat transfer takes place along the entire length of the heat exchanger 2 in order to obtain the largest possible heat

exchange.

[0037] Fig 2a-2d illustrate different steps of the method of manufacturing a plate heat exchanger according to one embodiment of the present invention.

[0038] In a first step, illustrated in fig 2a, the suitably profiled heat exchanger plates 4, 5 are stacked on eachother. The positioning of the individual plates needs to be executed with considerable precision, since it affects the subsequent manufacturing steps. In one embodiment, the plates are part of an uninterrupted strip of material 18.

[0039] As an alternative, plates 4, 5 may be provided separate from eachother prior to stacking.

[0040] In a subsequent step, illustrated in a cross-sectional, close-up view in fig 2b, the adjacent plates 4, 5 are brought into contact. Said bringing in contact is carried out by means of clamping means (not shown). Said clamping means may come in a variety of forms. In one embodiment, it is at least one gripping jaw. Typically, said gripping jaw is positioned in the plate sections where borders of the plates 22, 23 meet eachother. In this way, by engaging the jaw with the peripheral portions 20, 21 of the adjacent plates 4, 5, it is achieved that the peripheral portions of the two plates 20, 21 abut eachother prior to folding. Said gripping jaw remains engaged throughout the joint folding of the peripheral portions 20, 21 of the plates 4, 5. The size of the engagement zone is typically a few square milimeters. As it also may be seen, a border of the first heat exchanger plate 22 is arranged with an offset 24 to a corresponding border of the second heat exchanger plate 23. Consequently, the first border 22, 23 of the first and the second plate 4, 5 are not aligned. The size of the offset 24 is usually around 1 mm, although other values are envisageable.

[0041] In a following step, illustrated in a cross-sectional, close-up view in fig 2c, the folding of the plate portions 20, 21 is completed. Folding process will be more thoroughly described below, with reference to fig 3a - 3d. By way of example, said folding may be performed by means of at least one roll (not shown). The fold 26 is, in one embodiment, essentially cylinder-shaped. Its diameter is typically around 2 mm. Since said fold 26 normally is situated at the respective fluids inlet into the heat exchanger, the fold may be used to regulate the flow of the fluid into the heat exchanger.

[0042] In a subsequent step, illustrated in fig 2d, a sealant 28 is applied to the fully assembled heat exchanger 2. Said sealant 28 is normally applied to at least a part of a lateral surface 29 constituted by the heat exchanger plates. Purpose of the sealant 28 is to prevent any fluid leakage from the heat exchanger 2. Consequently, a tight seal is thereby achieved between the process fluids and the surroundings. By way of example a hot melt with a temperature of around 200 °C is used, but other sealing alternatives are envisageble.

[0043] By supplying heat exchanger plates 4, 5 in an uninterrupted strip of material 18, the stacking of the plates is simplified. Further on, the risk of fluid leakage originating from the lateral surface 29 of the heat exchanger 2 may be greatly reduced due to the inherent properties of the manufacturing method. Thus, a more robust heat exchanger 2 may be obtained.

[0044] By using said gripping jaw, appropriate folding is facilitated. Furthermore, by providing an offset 24 between the adjacent plates the folding of the peripheral portions 20, 21 of the plates is simplified.

[0045] By executing the folding by means of at least one roll, the folding is performed in a controlled and precise manner.

[0046] By suitably sizing the fold 26, an increased efficiency of the heat exchanger 2 may be obtained. Furthermore, by suitably shaping the fold 26, noise levels generated by the operating heat exchanger 2 may be reduced.

[0047] By applying said sealant 28, an additional mechanical stability to the heat exchanger 2 may be provided.

[0048] Fig 3a-3d illustrate, by means of a cross-sectional view, different steps of the plate folding process according to one embodiment of the present invention.

[0049] As it may be seen in fig 3a, extreme peripheral portions 20, 21 of the adjacent plates 30, 32 are, as mentioned above with reference to fig 2b, at first, brought in direct contact with each other by means of a gripping jaw (not shown). Furthermore, a border 22 of the upper heat exchanger plate 30 is arranged with an offset to a corresponding border 23 of the lower heat exchanger plate 32. Thus, at one plate end, the lower plate 32 extends beyond the plate that is positioned on top of it 30. Consequently, the borders 22, 23 of the first and the second plate 4, 5 are not aligned.

[0050] In a subsequent step of the folding process, illustrated in fig 3b, a bending of the section of the peripheral portion 20 of the lower plate 32 is executed. As stated above, this bending may be done by means of a first rotating roll (not shown) that engages portion of said lower plate. Said roll is usually made in stainless steel. As a consequence of the direct contact with the plate the rotating roll exerts a pressure on the lower plate 32, achieving thereby adequate bending of the plate portion 20.

[0051] In a following step of the folding process, illustrated in fig 3c, a further bending of the section of the peripheral portion 20 of the lower plate 32 and an initial bending of the peripheral portion 21 of the upper plate 30 is executed. Analoguosly to what has been stated above, this bending may be done by means of a second rotating roll (not shown) that simultaneously engages portions 20, 21 of both plates 30, 32.

[0052] In a subsequent step of the folding process, illustrated in fig 3d, and very similar to the step described in fig 3c, the sequential plate folding is completed. A fold 26 is thereby achieved.

[0053] As explained above, in order to render possible the plate folding, the rotating rolls are enabled to travel along the peripheral portion of the adjacent plates. Furthermore, successive bending of the peripheral portions

20, 21 of the plates 30, 32 is initiated by the first roll and continued and also eventually completed by the subsequent rolls. For satisfactory folding, it is important that the heat exchanger plates 30, 32 are parallel and plane during the entire folding process.

[0054] Number of rolls employed in the folding process may vary, depending on the size of the plates 30, 32 as well as size of the fold. Said rolls may be made in a variety of materials. Other means of folding than rotating rolls are equally conceivable.

[0055] Fig 4a is a cross-sectional view of peripheral portions 20, 21 of the adjacent plates 30, 32 comprising a fold 26 that has been described above, with reference to fig 3a - 3d.

[0056] As it may be seen, the extreme peripheral portions 20, 21 of the adjacent plates 30, 32 are folded together in order to create said fold 26. In one embodiment, the fold 26 has a circular cross-section, but other shapes, such as elliptical, are equally conceivable. Furthermore, size of the fold 26 depends on the distance between two adjacent heat exchanger plates 30, 32. In general, shape and size of the fold 26 are dependent on the application field of the heat exchanger. Further on, next to the folded portion of the two plates, there is a portion of the respective plate 30, 32 where the two plates are brought into direct contact with eachother.

[0057] Fig 4b is a front view of the fold shown in Fig 4a.

[0058] As it may be seen, the outer surface 35 of the fold 26 is provided with recesses 36. Recess pattern may vary according to the requirements of use. Said recesses 36 may, by way of example, be made using a roll (not shown) oriented substantially perpendicularly to the longitudinal axis of the fold 26. The purpose of the recesses 36 is to prevent the unfolding of said fold 26. The unfolding may occur due to the elevated internal fluid pressure in the heat exchanger.

[0059] Fig 5 is a perspective view of an air-air countercurrent heat exchanger 37 according to one embodiment of the present invention.

[0060] As it may be seen, said heat exchanger 37 has hexagonal longitudinal cross-section. As described in connection with Fig 1, the heat exchanger 37 is constituted of a plurality of stacked and suitably profiled heat exchanger plates. Further on, as stated above, a suitable sealant 28, such as hot melt, is applied to at least a part of a lateral surface 29 constituted by the heat exchanger plates. Thus, said sealant 28 may also be applied to the portions of the lateral surface 29 where, according to this embodiment, folding is not performed. The hot melt ensures that the fluid flow channels are hermetically sealed off from the surroundings. In this embodiment, the mutually parallel lateral sides 38, 40, both of them provided with folds along the plate borders, are used as inlet and the outlet of the respective fluid. An end plate 42 is mounted on the top surface 44 of the assembled heat exchanger 37. Its purpose is to provide additional mechanical stability as well as protection against undesirable external influences.

[0061] Heat exchanger plates are normally made in a material with high heat conductivity, such as aluminium or steel. Alternatively, a polymer material is used. For some applications heat exchanger plates may be provided with a hydrophobic coating that could be achieved by means of a polymer foil. Alternative longitudinal cross-sections are conceivable. End plates may be mounted on any of the surfaces of the heat exchanger as well as on any portion of the lateral surface.

[0062] General operating principle of the heat exchanger according to said embodiment of the present invention has been described with reference to fig 1.

[0063] Primary application field for the plate heat exchanger according to the present invention is the heat exchange between two gases, in particular air, but even other media such as steam or liquid should be envisaged, whereas slight modifications of the original design might be required.

[0064] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Claims

1. A method of manufacturing a plate heat exchanger (2) said method comprising the steps of

   - providing a first heat exchanger plate (4),
   - covering the first heat exchanger plate (4) with at least a second heat exchanger plate (5),
   - folding portions of the two heat exchanger plates (4,5) together along at least a section of at least one border associated with said plates to form a fold (26)
   - applying a sealant, said sealant being applied to at least a part of a lateral surface constituted by said heat exchanger plates,

   characterized in that said fold (26) has an elliptical cross-section.

2. A method of manufacturing a plate heat exchanger according to claim 1, whereby at least said first and second heat exchanger plate are being part of an uninterrupted strip of material.

3. A method of manufacturing a plate heat exchanger according to any of the preceding claims, said method further comprising the step of providing at least a part of an outer surface of the fold with indentations.

4. A method of manufacturing a plate heat exchanger according to any of the preceding claims, said method further comprising the step of providing at least

one surface constituted by said heat exchanger plates with an end plate.

5. A method of manufacturing a plate heat exchanger according to any of the preceding claims, whereby said folding is carried out by means of at least one roll.

6. A method of manufacturing a plate heat exchanger according to any of the preceding claims, whereby said fold is essentially cylinder-shaped with the diameter that is preferably between 1,5 mm and 2,5 mm, more preferred between 1,7 and 2,3 mm and most preferred between 1,9 and 2,1 mm.

7. A method of manufacturing a plate heat exchanger according to any of the preceding claims, said method further comprising the step of providing at least one heat exchanger plate with a hydrophobic coating.

8. A method of manufacturing a plate heat exchanger according to any of the preceding claims, said method further comprising the step of bringing in contact a portion of the first heat exchanger plate with a portion of the second heat exchanger plate along at least a part of at least a first border whereby said step is carried out by means of clamping means.

9. A method of manufacturing a heat exchanger according to any of the preceding claims, said method further comprising the step of arranging a first border of the first heat exchanger plate with an offset to a first border of the second heat exchanger plate.

10. A method of manufacturing a plate heat exchanger according to claim 9, whereby said offset is preferably between 0,5 and 1,5 mm, more preferred between 0,7 and 1,3 mm and most preferred between 0,8 and 1,2 mm.

11. A plate heat exchanger (2) comprising at least three stacked heat exchanger plates, wherein two adjacent plates (4, 5) are interconnected along at least a part of at least a first border associated with said plates by a fold (26), said fold being constituted of peripheral portions of said adjacent plates, and wherein a sealant is applied to at least a part of a lateral surface constituted by said at least three stacked heat exchanger plates, **characterized in that** said fold (26) has an elliptical cross-section.

12. A plate heat exchanger according to claim 11, wherein the thickness of the heat exchanger plate is preferably less than 110 microns, more preferred less than 100 microns and most preferred less than 95 microns.

13. A plate heat exchanger according to claim 11 or 12, wherein said heat exchanger is a countercurrent heat exchanger.

14. A plate heat exchanger according to any of the claims 11 - 13, wherein said fold is essentially cylinder-Shaped and the ratio between the diameter of the said fold and the vertical distance between the adjacent plates is preferably less than 1.5, more preferred less then 1.25, and most preferred less then 1.1.

Patentansprüche

1. **Verfahren zum Herstellen eines** Plattenwärmetauschers (2), wobei das Verfahren die folgenden Schritte umfasst:

- **Bereitstellen einer ersten** Wärmetauscherplatte (4);
- Bedecken der ersten Wärmetauscherplatte (4) **mit mindestens einer zweiten** Wärmetauscherplatte (5);
- Falten von Teilen der zwei Wärmetauscherplatten (4, 5) zusammen entlang mindestens eines Abschnitts von mindestens einem Rand, der mit den Platten zugehörig ist, um eine Falte (26) zu bilden;
- Auftragen von Dichtungsmittel, wobei das Dichtungsmittel auf mindestens einen Teil einer Seitenfläche aufgetragen wird, die von den Wärmetauscherplatten dargestellt wird,

dadurch gekennzeichnet, dass die Falte (26) einen elliptischen Querschnitt hat.

2. **Verfahren zum Herstellen eines** Plattenwärmetauschers nach Anspruch 1, wobei mindestens die erste und zweite Wärmetauscherplatte Teil eines ununterbrochenen Materialstreifens sind.

3. Verfahren zum Herstellen eines Plattenwärmetauschers nach einem der vorherigen Ansprüche, wobei das Verfahren ferner den Schritt des Bereitstellens von mindestens einem Teil einer Außenfläche der Falte mit Vertiefungen umfasst.

4. Verfahren zum Herstellen eines Plattenwärmetauschers nach einem der vorherigen Ansprüche, wobei das Verfahren ferner den Schritt des Bereitstellens von mindestens einer Fläche umfasst, die von den Wärmetauscherplatten mit einer Endplatte dargestellt wird.

5. **Verfahren zum Herstellen eines** Plattenwärmetauschers nach einem der vorherigen Ansprüche, wobei das Falten mittels mindestens einer Walze ausge-

führt wird.

6. **Verfahren zum Herstellen eines** Plattenwärmetauschers nach einem der vorherigen Ansprüche, wobei die Falte im Wesentlichen zylinderförmig ist, wobei der Durchmesser vorzugsweise zwischen 1,5 und 2,5 mm, stärker bevorzugt zwischen 1,7 und 2,3 mm und am besten zwischen 1,9 und 2,1 mm liegt.

7. Verfahren zum Herstellen eines Plattenwärmetauschers nach einem der vorherigen Ansprüche, wobei das Verfahren ferner den Schritt des Bereitstellens von mindestens einer Wärmetauscherplatte mit einer hydrophoben Beschichtung umfasst.

8. **Verfahren zum Herstellen eines** Plattenwärmetauschers nach einem der vorherigen Ansprüche, wobei das Verfahren ferner den Schritt der Kontaktherstellung eines Teils der ersten Wärmetauscherplatte mit einem Teil der zweiten Wärmetauscherplatte entlang zumindest eines Teils des mindestens einen ersten Randes umfasst, wobei der Schritt mit Hilfe von Klemmmitteln ausgeführt wird.

9. Verfahren zum Herstellen eines Wärmetauschers nach einem der vorherigen Ansprüche, wobei das Verfahren ferner den Schritt des Anordnens eines ersten Randes der ersten Wärmetauscherplatte mit einem Versatz zu einem ersten Rand der zweiten Wärmetauscherplatte umfasst.

10. Verfahren zum Herstellen eines Plattenwärmetauschers nach Anspruch 9, wobei der Versatz vorzugsweise zwischen 0,5 und 1,5 mm, stärker bevorzugt zwischen 0,7 und 1,3 mm und am besten zwischen 0,8 und 1,2 mm liegt.

11. Plattenwärmetauscher (2), der mindestens drei gestapelte Wärmetauscherplatten umfasst, wobei zwei benachbarte Platten (4, 5) miteinander entlang mindestens eines Teils von mindestens einem ersten Rand, der mit den Platten zugehörig ist, durch eine Falte (26) verbunden sind, wobei die Falte von peripheren Teilen der benachbarten Platten dargestellt wird un d wobei ein Dichtungsmittel auf mindestens einen Teil einer Seitenfläche aufgetragen wird, die durch die mindestens drei gestapelten Wärmetauscherplatten gebildet wird, **dadurch gekennzeichnet, dass** die Falte (26) einen elliptischen Querschnitt hat.

12. Plattenwärmetauscher nach Anspruch 11, wobei die Dicke der Wärmetauscherplatte vorzugsweise kleiner als 110 Mikrometer, stärker bevorzugt kleiner als 100 Mikrometer und am besten kleiner als 95 Mikrometer beträgt.

13. Plattenwärmetauscher nach Anspruch 11 oder 12, wobei der Wärmetauscher ein Gegenstrom-Wärmetauscher ist.

14. Plattenwärmetauscher nach einem der Ansprüche 11-13, wobei die Falte im Wesentlichen zylinderförmig ist und das Verhältnis zwischen dem Durchmesser der Falte und dem vertikalen Abstand zwischen den benachbarten Platten vorzugsweise kleiner als 1,5, stärker bevorzugt kleiner als 1,25 und am besten kleiner als 1,1 ist.

Revendications

1. Procédé de fabrication d'un échangeur de chaleur à plaques (2), ledit procédé comprenant les étapes consistant à :

   - fournir une première plaque d'échangeur de chaleur (4) ;
   - recouvrir la première plaque d'échangeur de chaleur (4) avec au moins une deuxième plaque d'échangeur de chaleur (5) ;
   - plier ensemble des parties des deux plaques d'échangeur de chaleur (4, 5) le long d'au moins une section d'au moins une bordure associée avec lesdites plaques pour former un pli (26) ;
   - appliquer un agent d'étanchéification, ledit agent d'étanchéification étant appliqué sur au moins une partie d'une surface latérale constituée desdites plaques d'échangeur de chaleur,

   caractérisé en ce que ledit pli (26) a une section transversale elliptique.

2. Procédé de fabrication d'un échangeur de chaleur à plaques selon la revendication 1, dans lequel au moins lesdites première et deuxième plaques d'échangeur de chaleur font partie d'une bande de matériau ininterrompue.

3. Procédé de fabrication d'un échangeur de chaleur à plaques selon l'une quelconque des revendications précédentes, ledit procédé comprenant en outre l'étape consistant à pourvoir d'échancrures au moins une partie d'une surface extérieure du pli.

4. Procédé de fabrication d'un échangeur de chaleur à plaques selon l'une quelconque des revendications précédentes, ledit procédé comprenant en outre l'étape consistant à pourvoir d'une plaque d'extrémité au moins une surface constituée desdites plaques d'échangeur de chaleur.

5. Procédé de fabrication d'un échangeur de chaleur à plaques selon l'une quelconque des revendications précédentes, dans lequel ledit pliage est réalisé au moyen d'au moins un rouleau.

6. Procédé de fabrication d'un échangeur de chaleur à plaques selon l'une quelconque des revendications précédentes, dans lequel ledit pli est essentiellement de forme cylindrique, le diamètre étant préférablement de 1,5 mm à 2,5 mm, plus préférablement de 1,7 mm à 2,3 mm, et idéalement de 1,9 mm à 2,1 mm.

7. Procédé de fabrication d'un échangeur de chaleur à plaques selon l'une quelconque des revendications précédentes, ledit procédé comprenant en outre l'étape consistant à pourvoir d'un revêtement hydrophobe au moins une plaque d'échangeur de chaleur.

8. Procédé de fabrication d'un échangeur de chaleur à plaques selon l'une quelconque des revendications précédentes, ledit procédé comprenant en outre l'étape consistant à mettre en contact une partie de la première plaque d'échangeur de chaleur avec une partie de la deuxième plaque d'échangeur de chaleur le long d'au moins une partie d'au moins une première bordure, ladite étape étant réalisée à l'aide d'un moyen de serrage.

9. Procédé de fabrication d'un échangeur de chaleur selon l'une quelconque des revendications précédentes, ledit procédé comprenant en outre l'étape consistant à disposer une première bordure de la première plaque d'échangeur de chaleur de telle sorte qu'elle présente un décalage par rapport à une première bordure de la deuxième plaque d'échangeur de chaleur.

10. Procédé de fabrication d'un échangeur de chaleur à plaques selon la revendication 9, dans lequel ledit décalage est préférablement de 0,5 mm à 1,5 mm, plus préférablement de 0,7 mm à 1,3 mm, et idéalement de 0,8 mm à 1,2 mm.

11. Échangeur de chaleur à plaques (2) comprenant au moins trois plaques d'échangeur de chaleur superposées, deux plaques adjacentes (4, 5) étant interconnectées le long d'au moins une partie d'au moins une première bordure associée avec lesdites plaques par un pli (26), ledit pli étant constitué de parties périphériques desdites plaques adjacentes, et un agent d'étanchéification étant appliqué sur au moins une partie d'une surface latérale constituée desdites au moins trois plaques d'échangeur de chaleur superposées, **caractérisé en ce que** ledit pli (26) a une section transversale elliptique.

12. Échangeur de chaleur à plaques selon la revendication 11, dans lequel l'épaisseur de la plaque d'échangeur de chaleur est préférablement inférieure à 110 microns, plus préférablement inférieure à 100 microns, et idéalement inférieure à 95 microns.

13. Échangeur de chaleur à plaques selon la revendication 11 ou 12, ledit échangeur de chaleur étant un échangeur de chaleur à contre-courant.

14. Échangeur de chaleur à plaques selon l'une quelconque des revendications 11 à 13, dans lequel ledit pli est essentiellement de forme cylindrique et le rapport entre le diamètre dudit pli et la distance verticale entre les plaques adjacentes est préférablement inférieur à 1,5, plus préférablement inférieur à 1,25, et idéalement inférieur à 1,1.

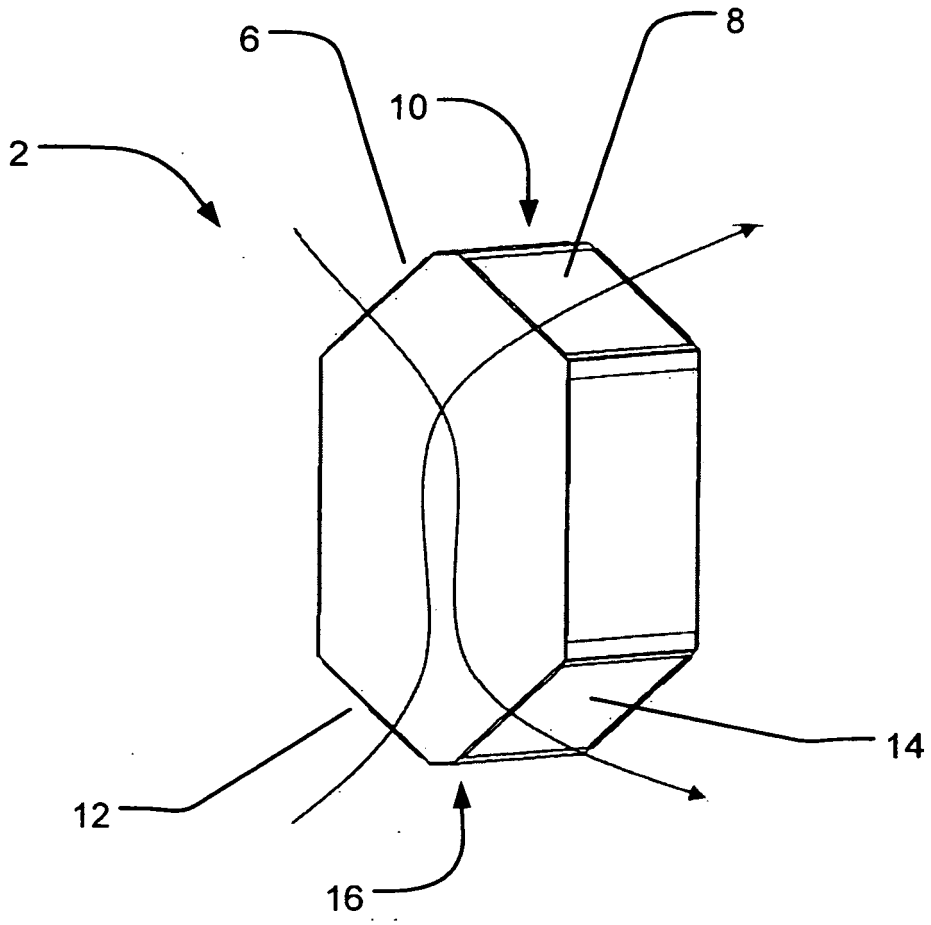


Fig 1

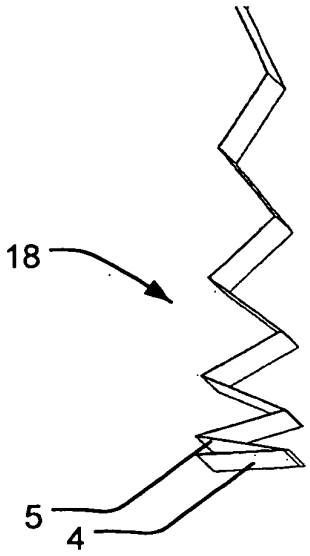


Fig 2a

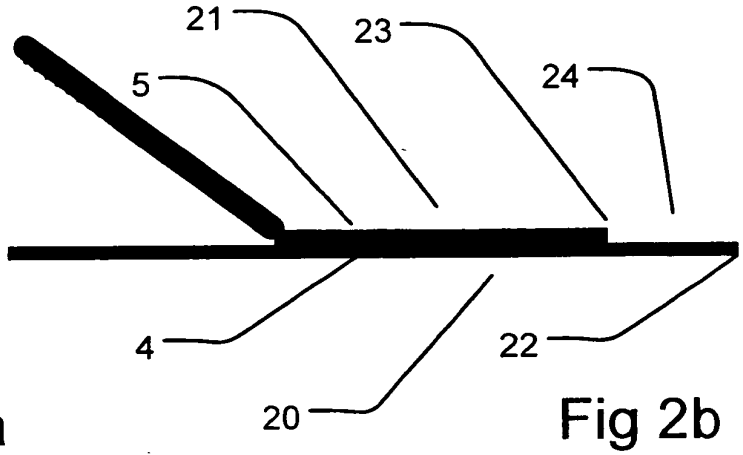


Fig 2b

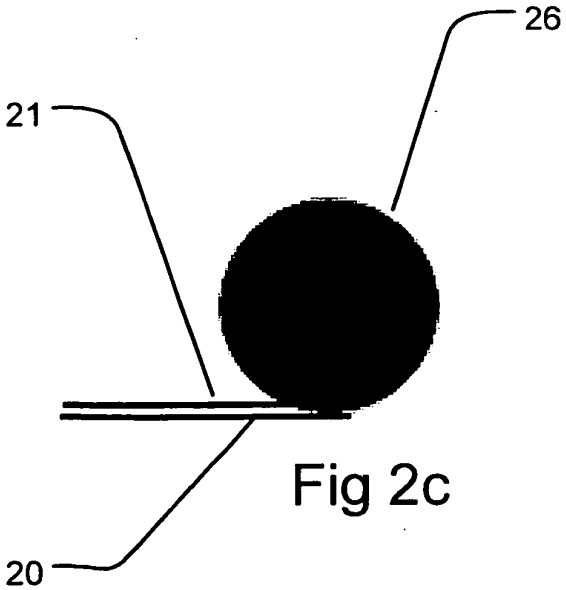


Fig 2c

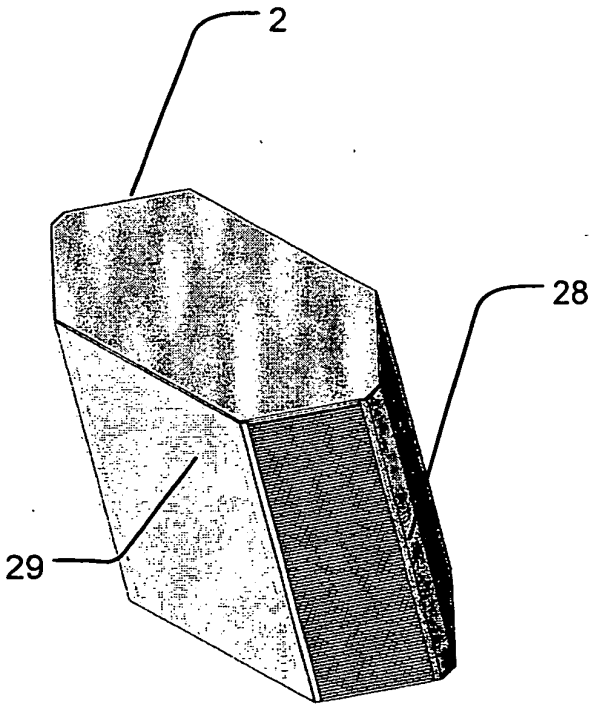


Fig 2d

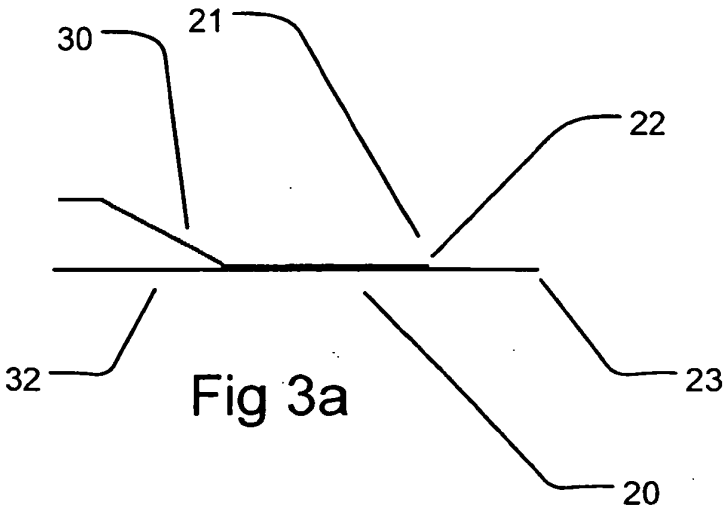


Fig 3a

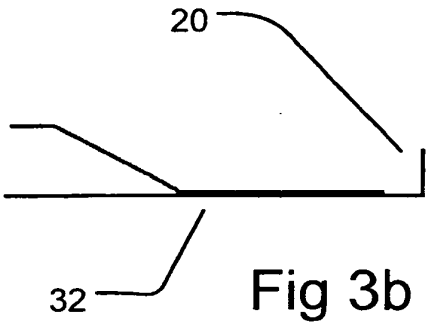


Fig 3b

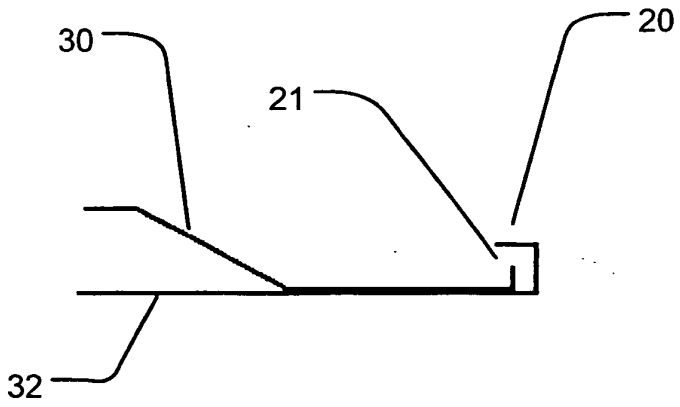


Fig 3c

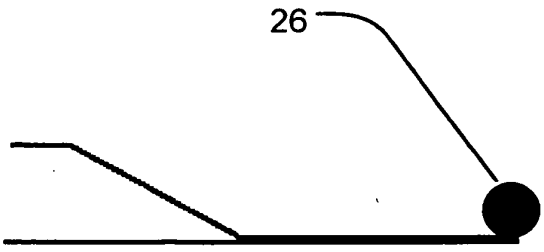


Fig 3d

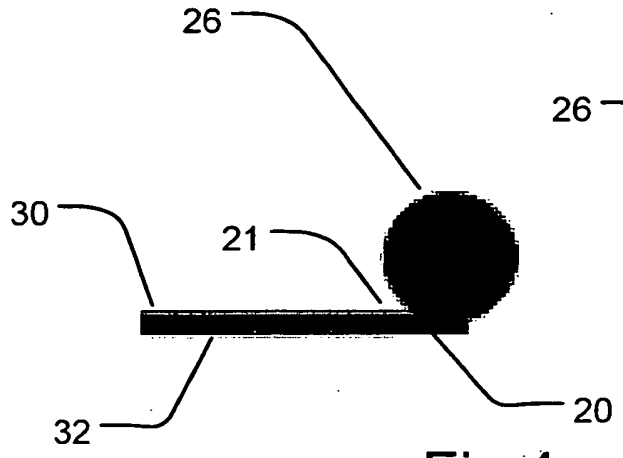


Fig 4a

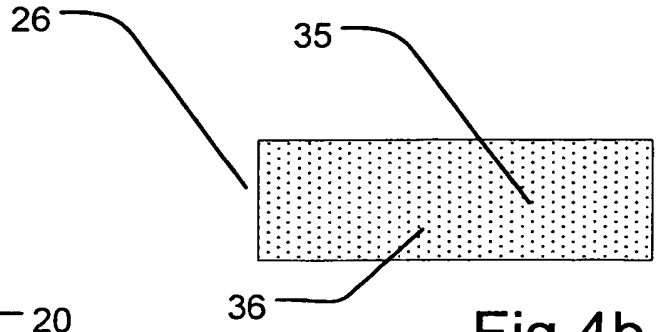


Fig 4b

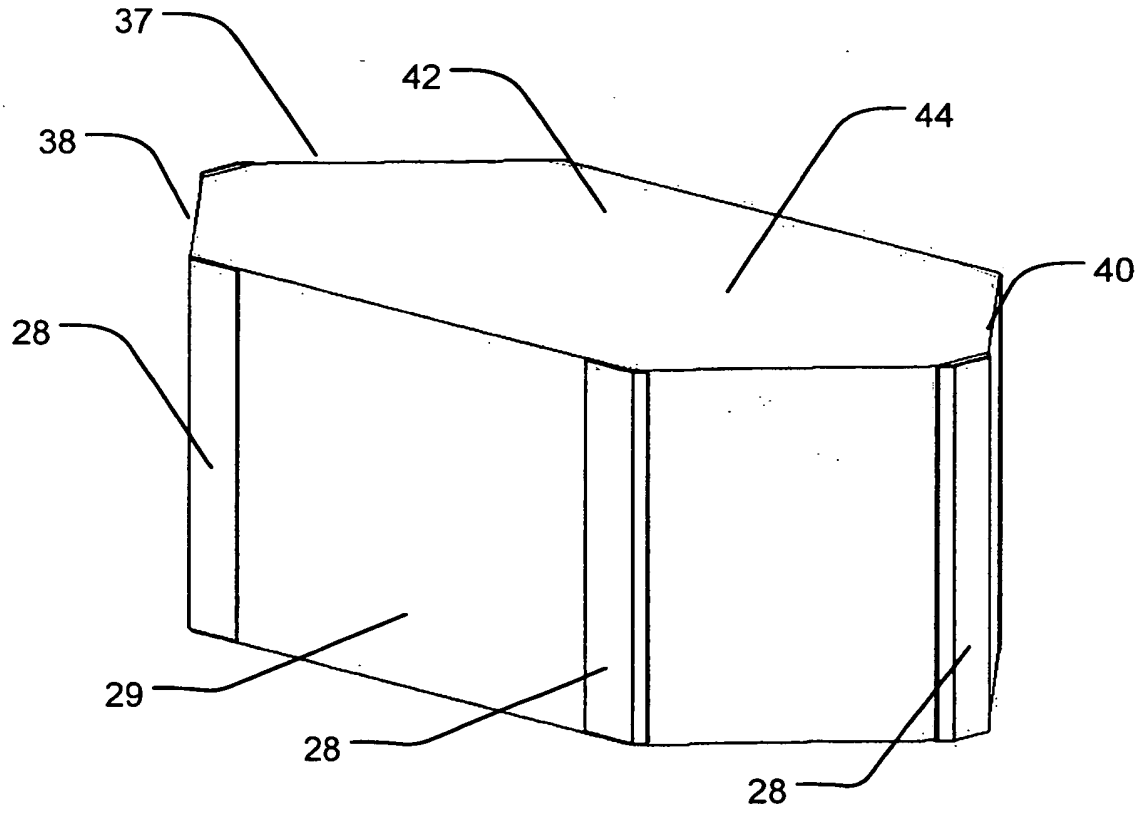


Fig 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2007071253 A **[0007]**
- EP 0167993 A **[0010]**