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(54) **HEAT EXCHANGER DEVICE**

(71) Applicant: **HS Marston Aerospace Limited**, Wolverhampton (GB)

(72) Inventor: **Berwyn POLLARD**, Wolverhampton (GB)

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(57) **ABSTRACT**

A multilayer heat exchanger device a frame constructed of multiple laminate layers that are bonded together. The device has a first fluid inlet manifold and a first fluid outlet manifold for connection to a supply and a return for the first fluid, the first fluid inlet manifold and the first fluid outlet manifold extending through the laminate layers of the frame; a second fluid inlet manifold and a second fluid outlet manifold for connection to a supply and a return for the second fluid, the second fluid inlet manifold and the second fluid outlet manifold extending through the laminate layers of the frame.

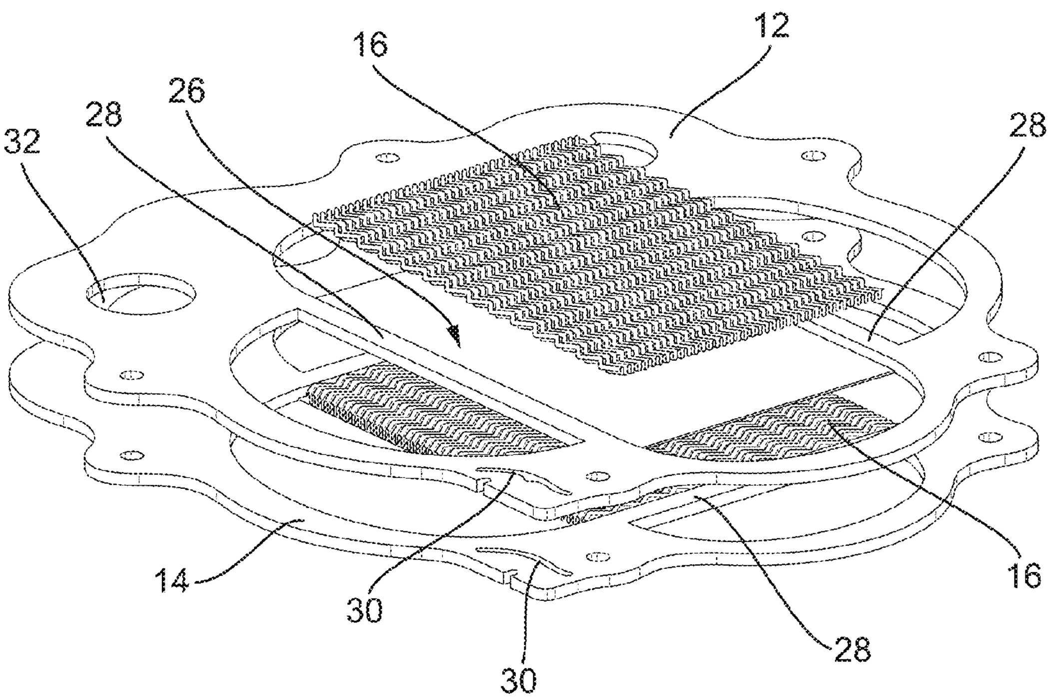


Fig. 1

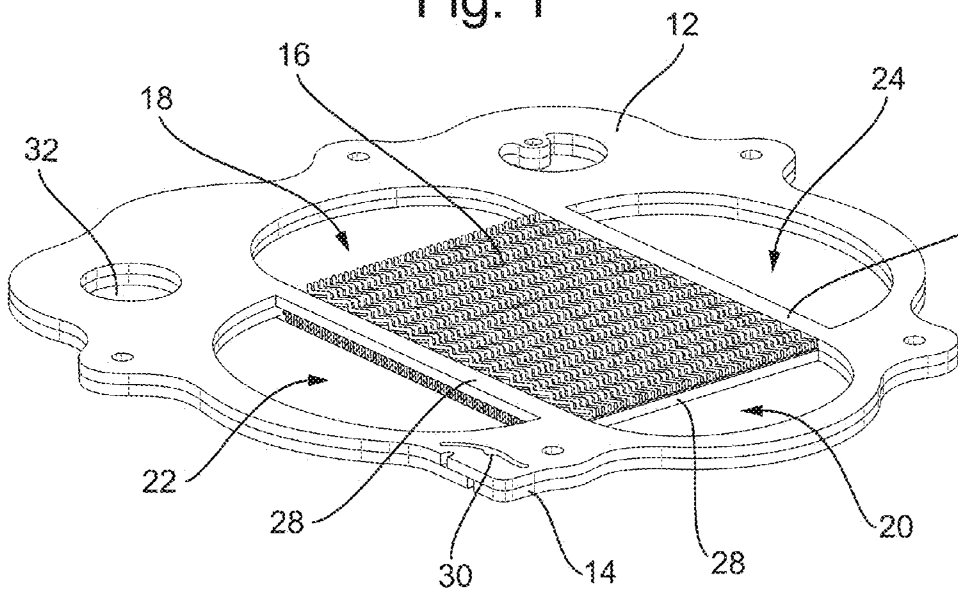
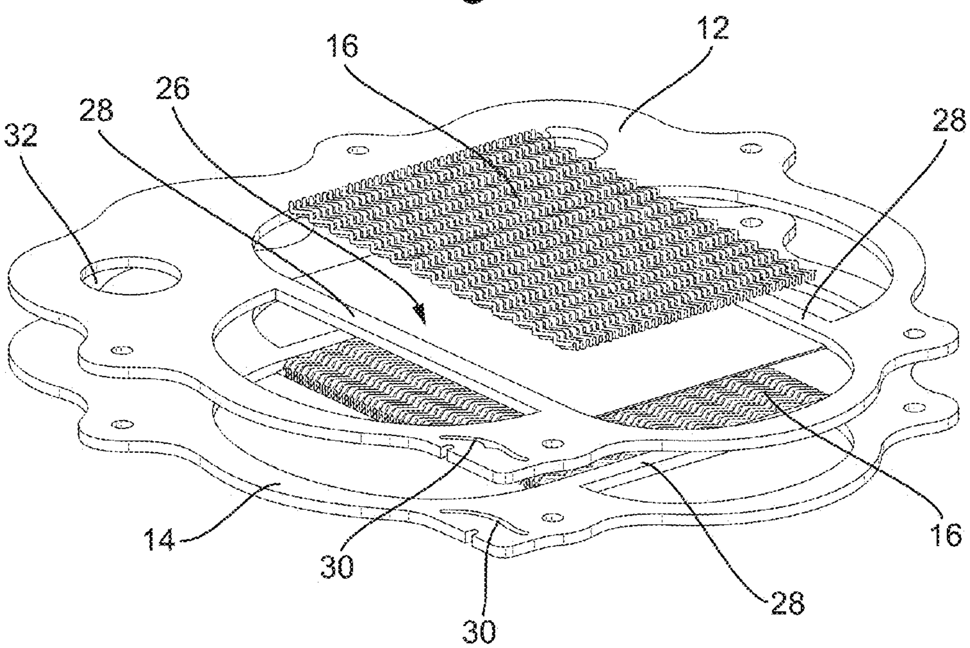


Fig. 2



HEAT EXCHANGER DEVICE

FOREIGN PRIORITY

[0001] This application claims priority to Great Britain Patent Application No. 1613732.5 filed Aug. 10, 2016, the entire contents of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The disclosure relates to a heat exchanger device and to a method for manufacturing a heat exchanger device. In an example implementation the heat exchanger device is for aerospace use.

BACKGROUND

[0003] Heat exchangers for transfer of heat between different fluids are very widely used and exist in various forms. Typically heat exchangers are arranged for flow of a primary fluid and a secondary fluid with heat being transferred between the two fluids as they flow through the device. Multi-stream heat exchangers for exchanging heat between more than two fluids also exist in the prior art. Some heat exchangers have a layered structure with a large number of parallel flow paths between plates that separate the flow paths. There may be 50-200 plates, or more, in this type of heat exchanger, typically with alternating hot/cold fluid flow paths either side of each plate.

[0004] US 2013/048261 discloses a laminate heat exchanger device with multiple laminate layers formed with corrugations to promote heat transfer. The laminates are stacked together and joined by brazing, diffusion bonding and/or welding along the adjacent surfaces of each pair of adjacent laminates. Jiggling features outside of the heat exchanging area are used during assembly to ensure that the various layers are aligned with each other. After the stack of laminate layers has been formed then manifold structures are attached to the outside of the stack for guiding flow of fluids into and out of the stack. For example, in the case of a two fluid system where heat is transferred between a primary fluid and secondary fluid then the manifolds would include a primary fluid inlet manifold, primary fluid outlet manifold, a secondary fluid inlet manifold and a secondary fluid outlet manifold. Thus, the heat exchanger device may be used for heat exchange with at least two fluids. Further manifolds could be added to allow for multi-stream arrangements with more than two fluids.

[0005] U.S. Pat. No. 6,427,764 discloses a layered heat exchanger where a frame has an integrated flow path for pressurised air, which exchanges heat with exhaust gases that flow through the heat exchanger via slots opening across each layer. The heat exchanger is formed as a plate fin arrangement where a frame is formed from the layers with corrugated flow guide plates between them, with the corrugated flow guide plates promoting parallel flow of the air and exhaust in opposite directions.

SUMMARY

[0006] Viewed from a first aspect, the invention provides a multilayer heat exchanger device for heat exchange between at least a first fluid and a second fluid, the device comprising: a frame constructed of multiple laminate layers that are bonded together; a first fluid inlet manifold and a first fluid outlet manifold for connection to a supply and a return for the first fluid, the first fluid inlet manifold and the first fluid outlet manifold extending through the laminate layers of the frame; a second fluid inlet manifold and a second fluid outlet manifold for connection to a supply and a return for the second fluid, the second fluid inlet manifold and the second fluid outlet manifold extending through the laminate layers of the frame; a plurality of first fluid flow paths for flow of the first fluid from the first fluid inlet manifold to the first fluid outlet manifold; a plurality of second fluid flow paths for flow of the second fluid from the second fluid inlet manifold to the second fluid outlet manifold; and a heat transfer region where the first fluid path and the second fluid path are in heat exchange relationship such that, in use, heat will be exchanged between the first fluid and the second fluid; wherein the multiple laminate layers comprise multiple first layers and multiple second layers in a repeating arrangement; wherein each of the first layers includes a first fluid flow path that passes through a cavity, the cavity being located at the heat exchanger region and being for receiving heat exchanger finstock, the cavity opening into the first fluid inlet manifold and the first fluid outlet manifold and being closed to the second fluid inlet manifold and the second fluid outlet manifold; and wherein each of the second layers includes a second fluid flow path that passes through a cavity, the cavity being located at the heat exchanger region and being for receiving heat exchanger finstock, the cavity opening into the second fluid inlet manifold and the second fluid outlet manifold and being closed to the first fluid inlet manifold and the first fluid outlet manifold.

[0007] This arrangement uses a layered frame structure with integrated manifolds for all of the fluid flow paths within the heat exchanger, whilst also allowing finstock of any required type to be held between the layers. Thus, the invention provides a hybrid arrangement that can combine the advantages of laminated type finstock, such as the complicated shapes available from layering etched layers to form the finstock, without the disadvantages that arise in relation to the attachment of manifolds to the exterior of laminated finstock. The layers of the heat exchanger frame are bonded together and as discussed below this may provide the structural strength for the heat exchanger, with there hence being no significant mechanical load on the finstock. This means that the finstock can advantageously have a material and construction that is optimised for maximum heat transfer, rather than needing to have structural properties as is the case in some prior art devices. The finstock could optionally be bonded to the frame layers, but this is not required and in some examples the finstock is simply held captive by the geometry of the cavity formed within the frame layers. The latter feature removes further constraints on the material and construction of the finstock, since it no longer needs to be capable of being joined to the material of the frame.

[0008] A multilayer heat exchanger device of the type set out in the first aspect has many layers with multiple fluid flow paths being arranged for heat exchange with adjacent fluid flow paths. The fluid flow paths may all be in parallel planes, and may have parallel flow paths with the same or different directions of flow, such as opposite flow directions or cross-flow. Thus, the layers may be generally planar in order that adjacent layers enclose a fluid flow path with the principle flow direction being parallel with the planes of the adjacent layers. A typical heat exchanger device has primary and secondary fluids flowing in parallel layers in different directions, which maximises the temperature differential between the fluids and thus gives the greatest rate of heat transfer.

[0009] The inlet and outlet manifolds each pass through the layers of the frame. The assembly of layers may hence form all of or a part of the manifolds, for example via a sequence of aligned throughholes in each layer. Thus, each layer may have a through hole for each manifold. In some examples the manifolds are located about the outside of the heat exchange region, and hence about the outside of the cavities in the layers. Each manifold may be at a side of the cavity with the number of sides corresponding to the number of manifolds. For example, in the case of only two fluids then there are four manifolds in total and these manifolds may be placed about four sides of the cavities, for example about four sides of a rectangular area such as a square. In that case the first fluid inlet and outlet may be at two opposite sides and the second fluid inlet and outlet may be at the other two opposite sides. The fluid flow paths may pass straight across the cavities in a cross-flow heat exchanger arrangement. Finstock may be provided in the cavities as discussed in further detail below in order to improve the heat transfer.

[0010] The manifolds may also provide jiggling features for use in assembly of the layers of the frame, or alternatively/additionally the layers may have separate jiggling features formed therein. The layers may also include throughholes for housing additional components of the heat exchanger device, such as valves, pumps, sensors and so on. In one example the layers have throughholes that align to form a valve housing when the layers are stacked together.

[0011] Whilst the use of two fluids in a heat exchanger is most commonplace, heat exchanger device such as that of the first aspect may be multistream heat exchangers with heat exchange between more than two fluids, for example three, or four, or more than four fluids. In that case the heat exchanger device may be provided with additional manifolds and fluid flow paths and thus there may be further layer types such as multiple third layers in addition to the multiple first layers and second layers.

[0012] The cavities of the layers may be open to the relevant inlet and outlet manifolds via openings extending through the depth of the layer and across the width of the manifold, which may hence form a slotted opening between the cavity and the manifold. The cavities of the layers may be closed to the other inlet and outlet manifolds by having no opening adjacent those manifolds, for example by the use of enclosure bars extending across the width of those manifolds. In the case of a two fluid heat exchanger device such one using the four sided arrangement described above then in the first layers the openings are along the two sides of the cavities that face the first fluid inlet manifold and first fluid outlet manifold whereas enclosure bars are along the two sides of the cavities that face the second fluid inlet manifold and second fluid outlet manifold, and in the second layers the openings are along the two sides of the cavities that face the second fluid inlet manifold and second fluid outlet manifold whereas enclosure bars are along the two sides of the cavities that face the first fluid inlet manifold and first fluid outlet manifold.

[0013] If a rectangular shape is used for the cavities then the heat exchanger region may extend over a cuboid volume with the manifolds formed outside of this cuboid region. The openings from the first layer cavities into the first fluid inlet manifold and first fluid outlet manifold may take the form a sequence of slotted gaps of the first layers in between the enclosure bars of the second layers, and openings from the second layer cavities into the second fluid inlet manifold and second fluid outlet manifold may take the form of a sequence of slotted gaps of the second layers in between the enclosure bars of the first layers.

[0014] The repeating arrangement for the layers may consist of an alternating sequence of each layer, for example alternating first and second layers where there are two layer types, or a repeated sequence of first layer, second layer and then third layer. More complicated layering arrangements may also be used, for example where one layer is present in pairs, such as by having one first layer, the two second layers, then another first layer and so on. This can be useful to allow for a greater flow volume and/or lower pressure drop for one fluid compared to another. Another way to vary the flow volume and/or pressure drop is for the first layers to have a different thickness than the second layers.

[0015] The layers include cavities for holding finstock, with the cavities being part of, or optionally the entirety of, the fluid flow paths from the inlet manifold to the outlet manifold. The fluid flow paths for the different fluids are separated and this may be done via parting sheets between the fluid flow paths. The parting sheets may be integrated with the layers or alternatively they may be integrated with the finstock and received in the cavity along with the finstock. In a further alternative the parting sheets may be separate from both the layers and the finstock. For example they may be separate sheets that are fitted to the layers along with the finstock. In the examples where the parting sheets are not integrated with the layers then they may be bonded to the layers, for example by brazing, diffusion bonding or adhesive.

[0016] The device may include finstock in the cavities. In particular there may be finstock that is separate to the layers, the finstock being held within the cavity of each layer. The finstock may be bonded to the layer, for example by brazing, diffusion bonding, welding or adhesive. This means that the finstock is securely fixed to the cavity and can increase the ease of handling of the layers with the finstock prior to assembly of the frame. However it can be an advantage for ease of manufacture of the device if the finstock is held within the cavity without bonding, for example it may be held securely by closed sides of the cavity and/or by tabs or lips at the open side of the cavity. In that instance the finstock and layers can be assembled very quickly by laying the various parts upon on another, optionally with the addition of separate parting sheets. In addition, since the finstock is not bonded to the layers then differences in thermal expansion of the finstock and the layers can be more readily accommodated without the generation of excessive stresses in the material of the finstock and/or layers of the frame.

[0017] The finstock may be formed by etching, stamping, moulding, punching and/or cutting, such as laser cutting, electron beam machining (EBM) cutting or electron beam (EB) cutting. The manufacturing technique used for the finstock can be different to that used for the layers of the frame. The finstock may include fins such as pin fins or any other known type of heat exchanger fins.

[0018] The frame layers are layers of a laminate structure that advantageously provides both guidance of fluid flows as well as structural strength. The laminated structure of the frame may provide the majority of the structural strength for the heat exchanger device, and the finstock may not be exposed to structural loads. The layers may be bonded together by any suitable technique taking account of the material of the layers and the operating conditions of the heat exchanger device. For example the layers may be bonded by brazing, diffusion bonding, welding or adhesives. In example embodiments there is no mechanical interconnection of the layers, i.e. there are no mechanical joins that clamp the layers or otherwise hold them together. One embodiment uses brazing to join the layers with each layer being provided with a suitable braze sheet prior to assembly along with the finstock, and the stack of layers being heated whilst being held together in order to form the brazed connections between the layers and complete the laminate structure of the frame.

[0019] The layers may be formed by etching, stamping, moulding, punching and/or cutting, such as laser cutting, EBM cutting or EB cutting. In some examples etching is used, optionally in conjunction with other techniques. Etching allows for accurate formation of shim type layers with low thicknesses and no unwanted deformation to the layers from the manufacturing process. This can provide a way to make a heat exchanger device with a high number of thin layers, which has advantages in relation to the heat transfer between the fluid flow paths, since a larger number of first and second fluid flow paths can be provided in a heat exchanger device of given size.

[0020] The thickness of the each of the layers may be less than 5 mm, optionally less than 1 mm. The heat exchanger device with a hybrid construction as described herein has particular advantages for laminated arrangements having many layers with low thickness.

[0021] As noted above, the use of separate finstock provides advantages in relation to the flexibility of choice of material and form for the finstock. Any fin arrangement may be used with this being selected with consideration of the heat exchange that is required, for example the nature of the fluid and the temperature of the fluid. The finstock may be manufactured from a different material than the layer and/or from a different material to the parting sheet. Different finstock may be used for each of the different types of layers, and thus there may be a first type of finstock held in the cavities of the first layers and a second type of finstock held within the cavities of the second layers, as well as optionally third and further types of finstocks for multistream heat exchangers.

[0022] The heat exchanger device may be for use with any required combination of fluids, such as liquid-liquid, liquid-gas or gas-gas heat exchange. Advantageously, by providing a laminated layered frame arrangement it becomes possible to easily handle a range of fluid types, temperatures and pressures. The geometry of the frame layers and/or the material(s) of the frame layers can be selected to suit the fluid characteristics, and the material can differ from the material of the heat exchanger finstock held by the frame. There is no need for a direct fluid-tight connection between the finstock and the frame, which further increases the degree of freedom in selection of materials. The proposed hybrid arrangement hence gives a wider range of possible applications. The heat exchanger may use air for heating or cooling of another fluid. In some examples the heat exchanger is for aerospace use and the invention thus extends to an aircraft including the heat exchanger device. In context of aerospace use the fluids could include two or more of: atmospheric air, cabin air, engine oil, generator oil, coolant, fuel and so on.

[0023] The material of the finstock and/or of the layers may be selected bearing in mind the intended use of the device and limitations arising from the temperatures and fluids involved in the use of the device. In particular, in some cases the material may be selected to withstand high or low temperatures, or to be resistant to potentially chemically reactive fluids such as fuel or coolant. The finstock and/or the layers may comprise aluminium and may be an aluminium alloy. Alternatively stainless steels or copper based materials may be used. It will be appreciated that metals such as aluminium can be readily etched, and that they provide a high conductance of heat. Non-metallic materials may also be possible, such as ceramic or plastic materials. As noted above the construction of the proposed device means that differing materials may be used for the finstock compared to for the layers. It is also possible to use different materials for the layers and/or finstock associated with the first fluid compared to the material used for the layers and/or finstock associated with the second fluid. Similarly, if third and optionally further fluids are used then the materials that are used could be different again.

[0024] The heat exchanger device is a multilayer structure with many layers, generally arranged in a repeating pattern in respect to the flow of fluids. There may for example be at least 40 layers, optionally at least 60 layers and in some cases 100 or more layers. The size and flow capacity of the heat exchanger device increases with the addition of more layers, which adds more flow paths, and thus layers may be added as required to provide the necessary performance. The thickness of the heat exchanger device as a whole is set by the layer thickness and the number of layers.

[0025] Viewed from a second aspect, the invention provides a method for manufacturing a multilayer heat exchanger device for heat exchange between at least a first fluid and a second fluid, the device comprising: a frame constructed of multiple laminate layers; a first fluid inlet manifold and a first fluid outlet manifold for connection to a supply and a return for the first fluid, the first fluid inlet manifold and the first fluid outlet manifold extending through the laminate layers of the frame; a second fluid inlet manifold and a second fluid outlet manifold for connection to a supply and a return for the second fluid, the second fluid inlet manifold and the second fluid outlet manifold extending through the laminate layers of the frame; a plurality of first fluid flow paths for flow of the first fluid from the first fluid inlet manifold to the first fluid outlet manifold; a plurality of second fluid flow paths for flow of the second fluid from the second fluid inlet manifold to the second fluid outlet manifold; and a heat transfer region where the first fluid path and the second fluid path are in heat exchange relationship such that, in use, heat will be exchanged between the first fluid and the second fluid; the method comprising: assembling the frame from the multiple laminate layers using multiple first layers and multiple second layers in a repeating arrangement; wherein each of the first layers includes a first fluid flow path that passes through a cavity located at the heat exchanger region, the cavity opening into the first fluid inlet manifold and the first fluid outlet manifold and being closed to the second fluid inlet manifold and the second fluid outlet manifold; and wherein each of the second layers includes a second fluid flow path that passes through a cavity located at the heat exchanger region, the cavity opening into the second fluid inlet manifold and the second fluid outlet manifold and being closed to the first fluid inlet manifold and the first fluid outlet manifold; wherein the assembling includes inserting finstock in each of the cavities and bonding the multiple laminate layers together to form the frame.

[0026] This method allows for effective manufacture of the heat exchanger device of the first aspect, and provides similar advantages. The method may include providing any of the features of the heat exchanger set out above.

[0027] The method may include forming all of or a part of the manifolds during assembly of the layers, for example via aligning a sequence of throughholes, with the throughholes being provided in some layers or optionally in all layers. The arrangement of the manifolds may be as discussed above.

[0028] The method may include using the manifold throughholes as jiggling features, or alternatively using dedicated jiggling feature for jiggling in order to align the layers of the frame prior to bonding them together.

[0029] In some examples the method includes forming the layers, and hence may comprise forming the each of the layers with the throughholes and cavity. The cavities may be open to the relevant inlet and outlet manifolds via openings extending through the depth of the layer and across the width of the manifold, which may hence form a slotted opening between the cavity and the manifold. The cavities may be closed to the other inlet and outlet manifolds by having no opening adjacent those manifolds, for example by forming the cavity with enclosure bars extending across the width of those manifolds. The layers and features of the layers such as the cavity may be as described above. The layers may be formed by etching, stamping, moulding, punching and/or cutting, such as laser cutting, EBM cutting or EB cutting. In some examples etching is used, optionally in conjunction with other techniques.

[0030] The layers may be bonded together by any suitable technique taking account of the material of the layers and the operating conditions of the heat exchanger device. For example the layers may be bonded by brazing, diffusion bonding, welding or adhesives. In example embodiments the method does not include using any mechanical interconnection of the layers in the final frame, i.e. there are no mechanical joins that clamp the layers or otherwise hold them together. One embodiment uses brazing to join the layers with each layer being provided with a suitable braze sheet prior to assembly along with the finstock, and the stack of layers being heated whilst being held together in order to form the brazed connections between the layers and complete the laminate structure of the frame.

[0031] The method includes assembling the frame with a repeating arrangement for the layers. This may consist of an alternating sequence of each layer, for example alternating first and second layers where there are two layer types, or a repeated sequence of first layer, second layer and then third layer. More complicated layering arrangements may also be used, as discussed above.

[0032] The fluid flow paths for the different fluids are separated and the method may include assembling the layers with parting sheets between the fluid flow paths. As discussed above the parting sheets may be integrated with the layers or alternatively they may be integrated with the finstock and received in the cavity along with the finstock, and in a further alternative the parting sheets may be separate from both the layers and the finstock.

[0033] The finstock may be separate to the layers, the finstock being held within the cavity of each layer. The finstock may be bonded to the layer, for example by brazing, diffusion bonding, welding or adhesive. Alternatively, the finstock may be held within the cavity without bonding, for example it may be held securely by closed sides of the cavity and/or by tabs or lips at the open side of the cavity. In that instance the method may comprise layering the finstock and layers upon on another without bonding them together, optionally with the addition of separate parting sheets.

[0034] The method may include forming the finstock, for example by etching, stamping, moulding, punching and/or cutting, such as laser cutting, EBM cutting or EB cutting. The manufacturing technique used for the finstock can be different to that used for the layers of the frame.

[0035] As noted above, the use of separate finstock provides advantages in relation to the flexibility of choice of material and form for the finstock. Different types of finstock may be used for the different layers as discussed above. The method may include selecting the geometry of the frame layers and/or the material(s) of the frame layers to suit the characteristics of the fluid that the heat exchanger device will be used with. The method may include selecting the material of the finstock and/or of the layers bearing in mind the intended use of the device and limitations arising from the temperatures and fluids involved in the use of the device.

[0036] In some examples the heat exchanger is for aerospace use and the invention thus extends to a method including installation of the heat exchanger on an aircraft and/or the steps relating to selecting the materials and so on may include selecting materials for aerospace use.

BRIEF DESCRIPTION OF THE FIGURES

[0037] Preferred embodiments of the invention are described below by way of example only and with reference to the accompanying drawings, in which.

[0038] FIG. **1** shows a repeating cell of a layered heat exchanger device; and

[0039] FIG. **2** shows an exploded view of the cell of FIG. **1**.

DETAILED DESCRIPTION

[0040] In an embodiment a heat exchanger device is assembled using multiple cells as shown in FIG. **1** and FIG. **2**. Each cell is made up of a first layer **12** and a second layer **14**. The heat exchanger device would have many such cells and hence a repeated arrangement of first layers **12** and second layers **14** in alternating sequence. The first layer **12** is for a first fluid and the second layer **14** is for a second fluid, with the heat exchanger device being for heat exchange between the first and second fluids in a heat exchange region.

[0041] The heat exchanger device includes finstock **16** in fluid flow paths that pass through the heat exchange region. The first and second layers **12**, **14** include throughholes that are located about the outside of the heat exchange region and align together to form manifolds for connection to supply and return for the first fluid and the second fluid. In this example there are four manifolds, being a first fluid inlet manifold **18** and a first fluid outlet manifold **20** for connection to a supply and a return for the first fluid, along with a second fluid inlet manifold **22** and a second fluid outlet manifold **24** for connection to a supply and a return for the second fluid. It will be appreciated that the location of the inlet and outlet manifolds could be reversed compare to how they are shown in the Figures.

[0042] The first layer **12** has a cavity **26** that is open to the first fluid inlet manifold **18** and the first fluid outlet manifold **20**, with enclosure bars **28** closing the cavity **26** from the second fluid inlet manifold **22** and the second fluid outlet manifold **24**. When the device is assembled then finstock **16** is inserted into the cavity **26** of the first layer and the first fluid can flow through the finstock **16** between the first fluid inlet manifold **18** and the first fluid outlet manifold **20**. The second layer **14** has a similar cavity (not shown) that is open to the second fluid inlet manifold **22** and the second fluid outlet manifold **24**, with enclosure bars **28** closing the cavity from the first fluid inlet manifold **18** and the first fluid outlet manifold **20**. Again, when the device is assembled then finstock **16** is inserted into the cavity of the second layer and the second fluid can flow through the finstock **16** between the second fluid inlet manifold **22** and the second fluid outlet manifold **24**. It will be appreciated that with a stack of cells of the type shown in FIG. **1** then when fluid connections for supply and return of the first and second fluids are made with the manifolds **18**, **20**, **22**, **24** then the first and second fluid will flow simultaneously through many parallel paths, with heat being exchanged along the extent of the stack of cells at the heat exchange region.

[0043] In this example the layers **12**, **14** include integrated parting sheets **26**, which act to separate the fluid flow paths. The parting sheets **26** could alternatively be separate parts, such as separate sheets that are assembled with the layers **12**, **14** along with the finstock **16**. The finstock **16** can be corrugated finstock **16** as shown in the Figures, for example etched shim finstock. Other types of finstock **16** could be used if required. The layers **12**, **14** may be manufactured by etching, which allows for relatively thin layers to be formed. In addition to the throughholes used to form the manifolds **18**, **20**, **22**, **24** the layers **12**, **14** further include jiggling features **30** for use in alignment of the layers **12**, **14** before they are bonded together. The layers **12**, **14** can also include other features, such as holes **32** for forming valve housings or the like.

[0044] Although the present disclosure has been described with reference to particular embodiments, the skilled reader will appreciate that modifications may be made that fall within the scope of the disclosure as defined by the appended claims. For example, there may be more than two fluids involved and thus there may be a third layer for a third fluid and an alternative configuration for all layers in order to allow for an additional inlet and outlet manifold. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

[0045] The term "about" is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

[0046] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

1. A multilayer heat exchanger device for heat exchange between at least a first fluid and a second fluid, the device comprising:

- a frame constructed of multiple laminate layers that are bonded together;
- a first fluid inlet manifold and a first fluid outlet manifold for connection to a supply and a return for the first fluid, the first fluid inlet manifold and the first fluid outlet manifold extending through the laminate layers of the frame;
- a second fluid inlet manifold and a second fluid outlet manifold for connection to a supply and a return for the second fluid, the second fluid inlet manifold and the second fluid outlet manifold extending through the laminate layers of the frame;
- a plurality of first fluid flow paths for flow of the first fluid from the first fluid inlet manifold to the first fluid outlet manifold;
- a plurality of second fluid flow paths for flow of the second fluid from the second fluid inlet manifold to the second fluid outlet manifold; and
- a heat transfer region where the first fluid path and the second fluid path are in heat exchange relationship such that, in use, heat will be exchanged between the first fluid and the second fluid;
- wherein the multiple laminate layers comprise multiple first layers and multiple second layers in a repeating arrangement;
- wherein each of the first layers includes a first fluid flow path that passes through a cavity, the cavity being located at the heat exchanger region and being for receiving heat exchanger finstock, the cavity opening into the first fluid inlet manifold and the first fluid outlet manifold and being closed to the second fluid inlet manifold and the second fluid outlet manifold; and
- wherein each of the second layers includes a second fluid flow path that passes through a cavity, the cavity being located at the heat exchanger region and being for receiving heat exchanger finstock, the cavity opening into the second fluid inlet manifold and the second fluid outlet manifold and being closed to the first fluid inlet manifold and the first fluid outlet manifold.

2. A multilayer heat exchanger device as claimed in claim **1**, wherein the inlet and outlet manifolds each pass through the layers of the frame, which hence form all of or a part of the manifolds.

3. A multilayer heat exchanger device as claimed in claim **1**, wherein the manifolds are located about the outside of the heat exchange region, and hence about the outside of the cavities in the layers, with each at a side of the cavities and the number of sides of the cavities corresponding to the number of manifolds.

4. A multilayer heat exchanger device as claimed in claim **1**, wherein the cavities of the layers are open to the relevant inlet and outlet manifolds via openings extending through the depth of the layer and across the width of the manifold, and the cavities of the layers are closed to the other inlet and outlet manifolds by having no opening adjacent those manifolds.

5. A multilayer heat exchanger device as claimed in claim **1**, wherein the fluid flow paths for the different fluids are separated by parting sheets.

6. A multilayer heat exchanger device as claimed in claim **5**, wherein the parting sheets are integrated with the layers.

7. A multilayer heat exchanger device as claimed in claim **5**, wherein the parting sheets are separate from both the layers and the finstock.

8. A multilayer heat exchanger device as claimed in claim **1**, comprising finstock in the cavities, the finstock being separate to the layers and held within the cavity of each layer.

9. A multilayer heat exchanger device as claimed in claim **8**, wherein the finstock has been formed by etching, stamping, moulding, punching and/or cutting, such as laser cutting, EBM cutting or EB cutting.

10. A multilayer heat exchanger device as claimed in claim **8**, wherein the manufacturing technique used for the finstock is different to that used for the layers of the frame and/or the finstock is manufactured from a different material than the material(s) of the layers.

11. A multilayer heat exchanger device as claimed in claim **1**, wherein the frame layers are layers of a laminate structure that provides all of or the majority of the structural strength for the heat exchanger device.

12. A multilayer heat exchanger device as claimed in claim **1**, wherein the finstock is not exposed to structural loads.

13. A multilayer heat exchanger device as claimed in claim **1**, wherein the layers are be bonded together by brazing, diffusion bonding, welding or adhesives.

14. A multilayer heat exchanger device as claimed in claim **1**, wherein there is no mechanical interconnection of the layers aside from the bonding between the layers.

15. A multilayer heat exchanger device as claimed in claim **1**, wherein the layers are formed by etching, stamping, moulding, punching, cutting, laser cutting, electron beam machining (EBM) cutting or electron beam (EB) cutting.

16. A multilayer heat exchanger device as claimed in claim **1**, wherein the thickness of the each of the layers is less 5 mm, optionally less than 1 mm.

17. A multilayer heat exchanger device as claimed in claim **1**, wherein the heat exchanger device includes at least 40 layers.

18. An aircraft including a multilayer heat exchanger device as claimed in claim **1**.

19. A method for manufacturing a multilayer heat exchanger device for heat exchange between at least a first fluid and a second fluid, the device comprising:

a frame constructed of multiple laminate layers; a first fluid inlet manifold and a first fluid outlet manifold for connection to a supply and a return for the first fluid, the first fluid inlet manifold and the first fluid outlet manifold extending through the laminate layers of the frame; a second fluid inlet manifold and a second fluid outlet manifold for connection to a supply and a return for the second fluid, the second fluid inlet manifold and the second fluid outlet manifold extending through the laminate layers of the frame; a plurality of first fluid flow paths for flow of the first fluid from the first fluid inlet manifold to the first fluid outlet manifold; a plurality of second fluid flow paths for flow of the second fluid from the second fluid inlet manifold to the second fluid outlet manifold; and a heat transfer region where the first fluid path and the second fluid path are in heat exchange relationship such that, in use, heat will be exchanged between the first fluid and the second fluid;

the method comprising:

assembling the frame from the multiple laminate layers using multiple first layers and multiple second layers in a repeating arrangement; wherein each of the first layers includes a first fluid flow path that passes through a cavity located at the heat exchanger region, the cavity opening into the first fluid inlet manifold and the first fluid outlet manifold and being closed to the second fluid inlet manifold and the second fluid outlet manifold; and wherein each of the second layers includes a second fluid flow path that passes through a cavity located at the heat exchanger region, the cavity opening into the second fluid inlet manifold and the second fluid outlet manifold and being closed to the first fluid inlet manifold and the first fluid outlet manifold;

wherein the assembling includes inserting finstock in each of the cavities and bonding the multiple laminate layers together to form the frame.

20. A method as claimed in claim **19**, comprising providing features of the heat exchanger device as claimed in claim **1**.

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