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(54) **BRAZED HEAT EXCHANGER AND PRODUCTION METHOD**

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(57) **ABSTRACT**

The invention relates to a heat exchanger which is brazed in a brazing furnace, comprising stacked heat exchanger parts which provide first channels and second channels, and with at least two brazing materials, the one brazing material in the first channels being different than the other brazing material in the second channels. According to one alternative, said heat exchanger is improved by virtue of the fact that there is the other or the one brazing material in one or in a few of the first channels or the second channels or in one or in a few of the first and the second channels, or the other and the one brazing material are present arranged in part regions.

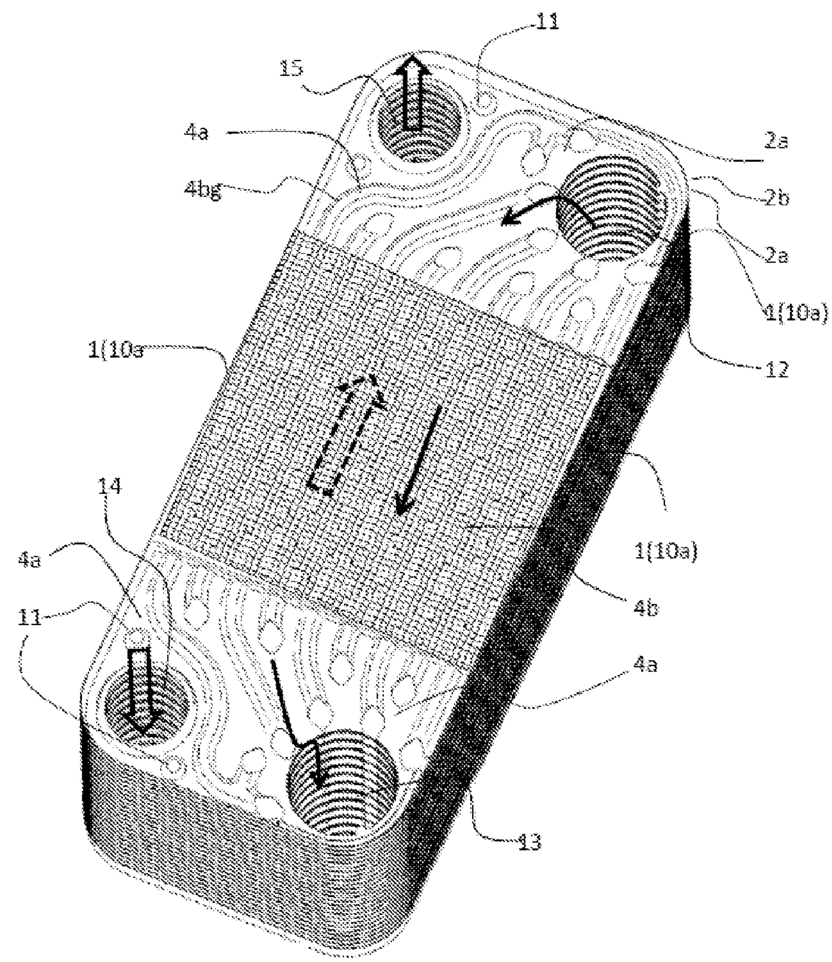


FIG. 1

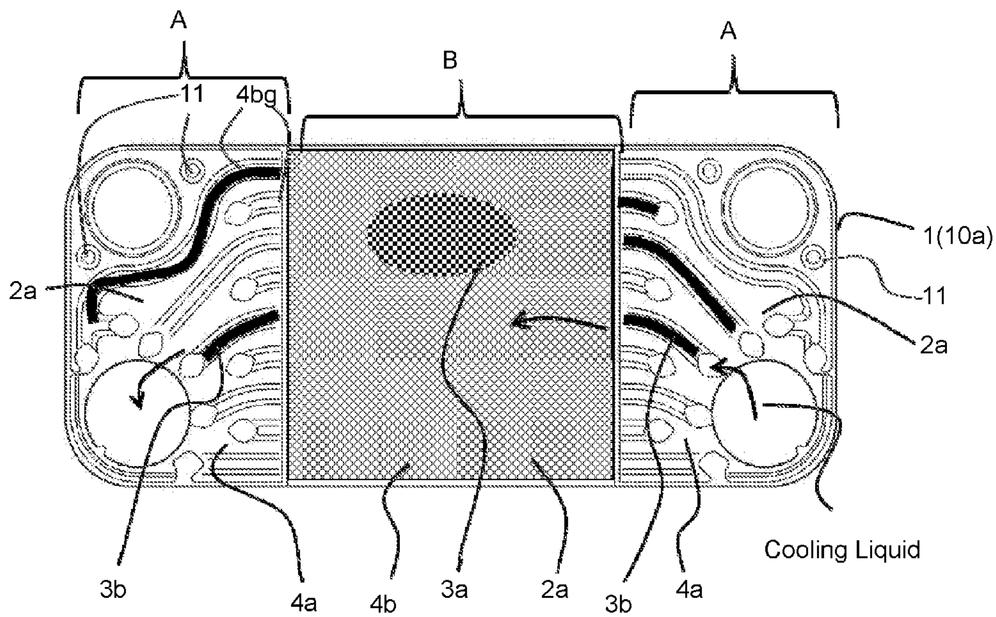


FIG. 2

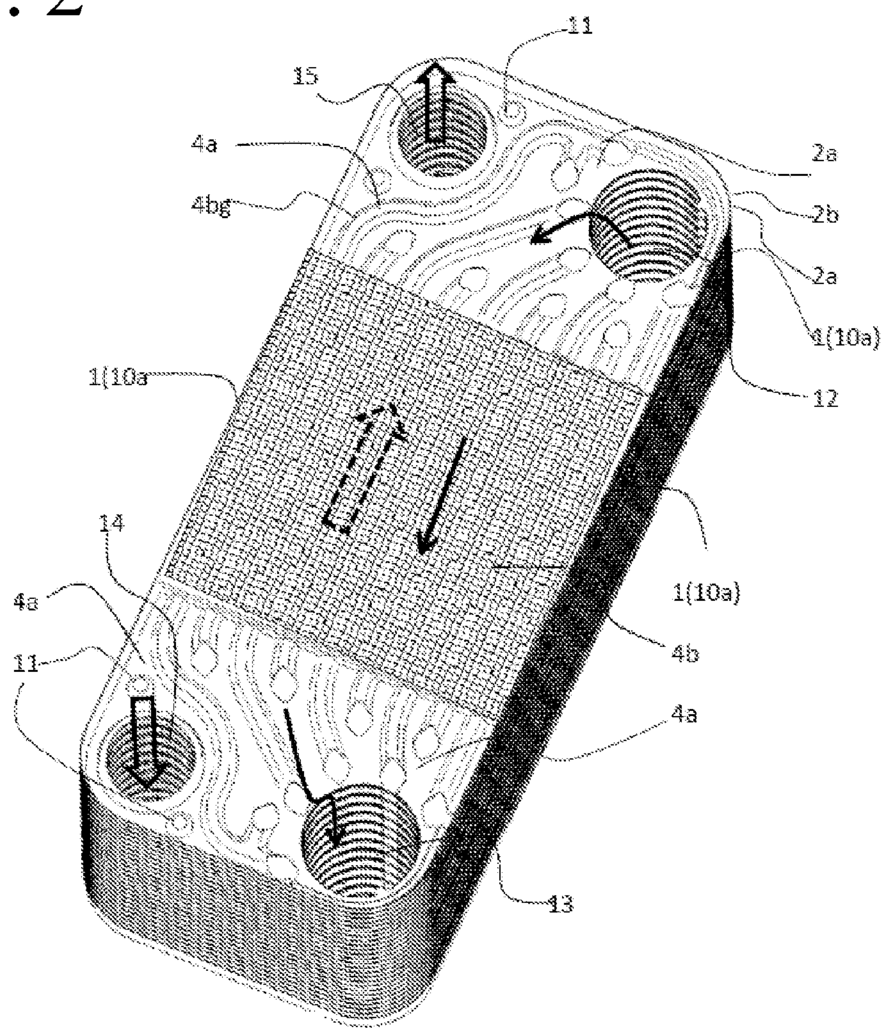


FIG. 3

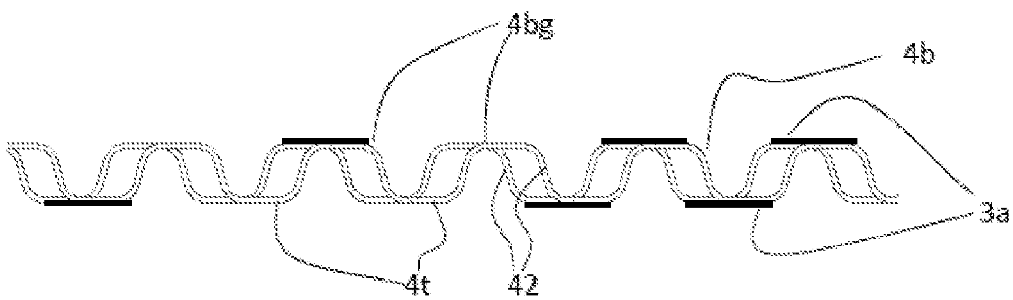
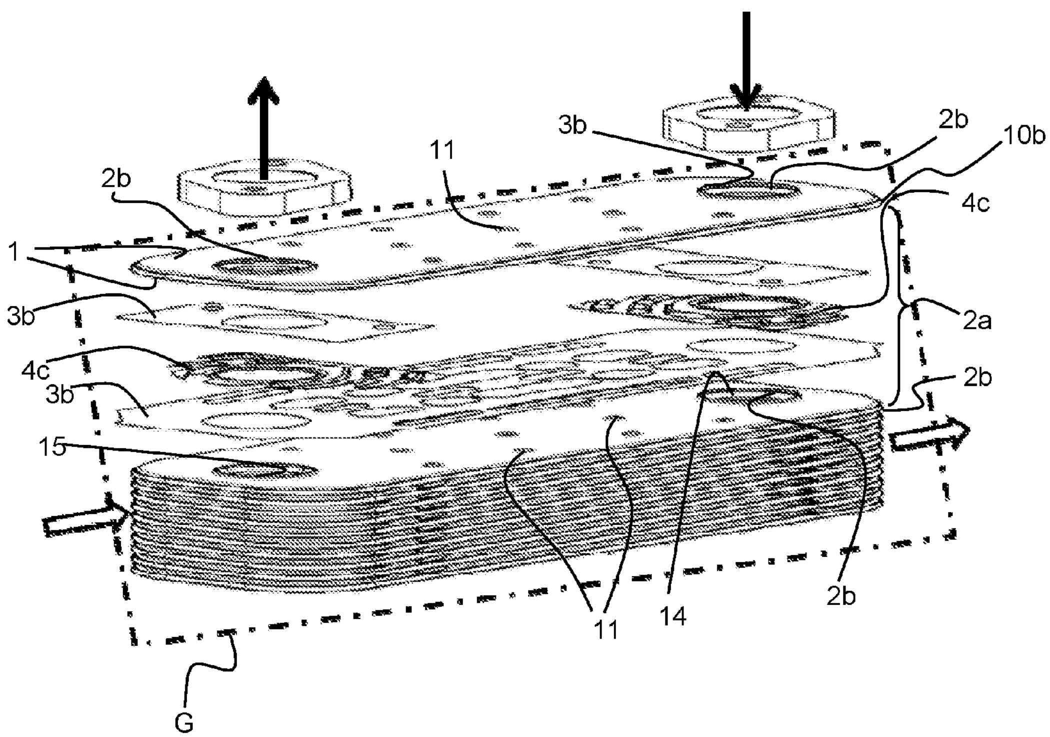


FIG. 4



BRAZED HEAT EXCHANGER AND PRODUCTION METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to German Patent Application No. 10 2015 010310, filed Aug. 8, 2015, the entire contents of which are hereby incorporated by reference herein.

BACKGROUND

[0002] The invention relates to a heat exchanger which is brazed in a brazing furnace, comprising stacked heat exchanger parts which provide first and second channels, and with brazing material, at least arranged in brazed connection seams, the one brazing material on surfaces in the first channels being different than the other brazing material on other surfaces in the second channels. The invention also relates to production methods for said heat exchangers.

[0003] A heat exchanger of this type with a production method was filed recently at the DPMA and received the reference number DE 10 2014 015 170.0.

[0004] The different brazing materials are preferably brazing materials based on different substances, for example copper brazing materials and iron brazing materials.

[0005] Certain alloy constituent parts, of which it is said that they might trigger disadvantageous effects in connected circuits in dissolved form, can be eliminated by way of the heat exchanger of the earlier application, and costs can also possibly be reduced.

[0006] In the meantime, the applicant has carried out practical test series and has determined that there is further need for improvement. This applies, for example, with regard to the higher strength which is necessary for many applications of the heat exchanger.

SUMMARY

[0007] It is the object of the invention to improve the heat exchanger from the earlier application. Improved strength properties are to be achieved by way of one particularly preferred exemplary embodiment.

[0008] According to the invention, this object is achieved by way of a heat exchanger which is brazed in a brazing furnace.

[0009] According to one important aspect of the invention, it is provided that the one brazing material is preferably present at least partially in an upper and/or lower channel of the first or second channels of the heat exchanger which are assigned to the first or the second medium, and that the other brazing material is arranged in the remaining first or in the remaining second channels for the same medium.

[0010] This does not necessarily have to be the uppermost or the lowermost channel. In general, this means equipping one channel or some channels on one medium side or even on both medium sides at least partially with another brazing material than the other remaining channels on the respective medium side, in order to provide the heat exchanger with the advantages which are to be assigned to said other brazing material.

[0011] With regard to strength, actually only the one uppermost and/or the one lowermost channel are/is of significance in practice, because the greatest loads will occur there and the strength is therefore to be increased there. This can be the first channel which lies below a cover plate or above a base plate and/or can also be, for example, the second channel, namely depending on the respective medium side which is to be reinforced.

[0012] It should be understood that the proposed embodiment of the uppermost and/or the lowermost channels can also be present on both medium sides of the heat exchanger, if a special application should require an embodiment of this type.

[0013] An alternative solution according to the invention provides that there is at least one first part region in all of the first channels or in all of the second channels, in which part region the one brazing material is arranged, and there is at least one second part region, in which the other brazing material is arranged.

[0014] The invention proceeds, inter alia, from the knowledge that, for example, a copper-based brazing material which contains almost exclusively copper can provide a higher strength than, for example, an iron-based brazing material which has different other alloy constituent parts.

[0015] One result of the tests which were addressed in the introductory part has proven to be that no damage caused by dissolution of copper occurred in the connected circuits as a result of the provision of copper brazing substance merely in the upper and the lower channel, which are loaded the most with regard to strength, of the first or the second channels. All of the remaining first or the remaining second channels, which therefore represent the majority of the channels, have namely been equipped with an iron-based brazing material, as in the earlier application. The overall quantity of, for example, copper therefore still remains below a threshold which triggers supposed damage.

[0016] This also applies to aforementioned alternative solution because the part regions which are provided with copper brazing substance in the first or in the second channels are relatively small.

[0017] In addition, one particularly preferred exemplary embodiment of the heat exchanger arranges for not providing the uppermost and/or the lowermost channel completely with copper brazing substance, but rather only partially, as a result of which the quantity of copper used is reduced further, but the strength can be increased to a sufficient extent, in comparison with the earlier application. The remaining brazing substance in the upper and/or in the lower channels can be an iron-based brazing substance. In this context, "partially" is therefore to be understood to mean that there are areas in said channels which have the copper brazing substance and other areas in the same channels which are provided with the iron brazing substance.

[0018] In a heat exchanger according to an embodiment of the invention, the heat exchanger parts of which, which form the channels, are heat exchanger plates which are stacked inside one another and have two inlets and two outlets, the addressed areas with the copper brazing substance are mainly those which are situated in a region around the inlets and outlets. In contrast, the addressed other areas within the channels which are provided with the iron brazing substance are those areas which are present in a middle plate or channel region between the inlets and outlets.

[0019] If the heat exchanger is an oil cooler which is cooled by means of liquid, it is provided in one very particularly preferred exemplary embodiment, in simple terms, to equip all of the channels which are assigned to the oil with the copper brazing material. In the liquid channels, in contrast, the uppermost and/or the lowermost channel are/is provided (partially) with the copper brazing material, whereas all the remaining channels for the liquid are provided completely with the iron brazing material.

[0020] The brazed heat exchangers according to some embodiments of the invention comprise, as a first type, what are known as "caseless" heat exchangers, in which the heat exchanger parts are usually configured as trough-shaped plates which are stacked inside one another. Heat exchanger plates of this type have at least four openings which, as has already been mentioned, form four inlet or outlet channels which extend through the stack. One inlet channel and one outlet channel are assigned to in each case one medium. In said first heat exchanger type, all the channels are closed channels. Closed channels are those which are closed all around by means of connected plate edges.

[0021] The heat exchangers according to some embodiments of the invention also include those of a second type which has a housing, in which the stack is arranged. As heat exchanger parts, said stack has tubes or else plate pairs and fins which form tubes or (as an alternative) lobes, between the tubes or the plate pairs, with closed channels in the tubes or plate pairs and with other, open channels, in which the fins or the lobes are arranged. If the heat exchanger parts are single-piece tubes, in particular flat tubes, they are closed at their opposite ends by way of crimping or folding, as known in the art.

[0022] Open channels are those which are at least partially open on the circumferential side, but are preferably completely open all the way around.

[0023] Said heat exchanger parts as a rule have merely two openings in the plates or in the flat tube walls, which openings form an inlet channel and an outlet channel in the plate stack for the medium which flows through the closed channels. The second medium flows into the housing and subsequently flows through the other channels which are open at least partially all around with the fins or the lobes between the plate pairs, in order to subsequently leave the housing.

[0024] Accordingly, the second heat exchanger type is distinguished by way of an alternation in the stack of closed channels with the open channels.

[0025] A suitable copper-based brazing material has a copper proportion of approximately 99% copper or even more.

[0026] A suitable iron-based brazing material contains, for example, 20% by weight chromium, 39% by weight iron and 20% by weight nickel and also 10% by weight copper and other alloy constituent parts in a relatively small quantity.

[0027] Another suitable iron-based brazing substance has 54% by weight iron and merely 15% by weight chromium and 10% by weight nickel and other alloy constituent parts, inter alia also 5% by weight copper.

[0028] Copper-based and iron-based brazing materials have been addressed up to now. This proposal is not to be restricted thereto, however. Rather, combinations of other known brazing materials or brazing alloys are to be included, it being possible for advantages which are to be attributed to said brazing material alloys to be achieved, for example an improvement with regard to resistance against corrosion, but also further cost reductions, etc. The different brazing materials should lie at least close to one another or be approximately identical with regard to their melting points, as has already been stated in the earlier application.

[0029] A heat exchanger according to the invention can also have more than two different brazing materials.

[0030] The first and the second medium can be different media or identical media (for example, two oils), but at different temperatures.

[0031] The following description of exemplary embodiments is particularly directed to those which have copper and iron brazing materials, in order to improve the strength of the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] FIGS. **1** to **3** show one exemplary embodiment using a "caseless" heat exchanger which has exclusively closed channels.

[0033] FIG. **4** shows one exemplary embodiment using a heat exchanger in a housing which has closed and open channels.

DETAILED DESCRIPTION

[0034] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the accompanying drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

[0035] The basic material of those parts of the heat exchangers which are shown in the exemplary embodiments is a stainless steel. In other exemplary embodiments which are not shown, it can be, for example, an aluminum alloy or another metal which can be brazed with correspondingly different brazing materials.

[0036] FIG. **1** shows a view into an uppermost channel **2*a*** which is preferably a cooling liquid channel. A heat exchanger part **1**, in particular a heat exchanger plate **1** with an obliquely raised edge **10*a*** can be seen. The edges **10*a*** of the plates **1** are connected in order to form the closed channels. Four holes are situated in said heat exchanger plates **1**. A further heat exchanger plate **1** is laid on top in order to form the liquid channel which is shown. Said further heat exchanger plate (not shown) might also be a cover plate which normally has somewhat thicker walls than a heat exchanger plate **1**. The upper left-hand and the upper right-hand hole is a part of an inlet channel and an outlet channel **14**, **15**, respectively. By means of said inlet and outlet channel **14**, **15**, the channel **2*b*** (not shown) which is adjacent toward the bottom, preferably an oil channel, is fed. The channels **2*a*** and **2*b*** alternate in the vertical plate stack direction, as is usually customary at any rate. The inlet and outlet channels **12**, **13**, **14**, **15** which are formed in this way are otherwise clearly visible in FIG. **2** which shows a perspective view of the plate stack. The lower right-hand and the lower left-hand hole and the inlet and outlet channels **12**, **13** which are formed from them in the plate stack are correspondingly provided for the cooling liquid. It can accordingly be assumed that the cooling liquid flows into the cooling liquid channel **2***a* which is shown at the bottom right and leaves said channel **2***a* again at the bottom left (FIG. **1**).

[0037] Furthermore, as is apparent from FIGS. **1** and **2**, in each case one corrugated channel plate **4***a* is situated in the upper liquid channel which is shown and preferably also in all other liquid channels of the heat exchanger, on the left and right in the inlet region and in the outlet region of the liquid channel. The corrugated channel plates **4***a* have in each case two openings which correspond in each case with one of the abovementioned holes in the plates **1**. The openings are therefore slightly larger than the holes. Furthermore, the channel plates **4***a* usually have arcuate corrugations which firstly lead from the inlet channel to a middle plate region and secondly lead from the middle plate region to the outlet channel. To this end, in each case apertures are arranged in the channel plates **4***a* at the ends of the corrugations. Where the corrugations are formed, the liquid can flow between the channel plate **4***a* and the lower heat exchanger plate **1**. Where the channel plates **4***a* are configured without corrugations, that is to say are of planar configuration, the liquid flows between the channel plate **4***a* and the upper heat exchanger plate **1**. In order to further improve the stability, individual lobes **11** are also present in the corrugated channel plates **4***a*.

[0038] In the abovementioned middle plate or channel region, a corrugated slat **4***b* is situated between the two channel plates **4***a*, the details of which corrugated slat **4***b* are shown in FIG. **3**. As is known, the corrugations of the channel plates **4***a* and the slats **4***b* have corresponding corrugation peaks **4***bg* and corrugation troughs **4***t*. The slat **4***b* has cuts in the corrugation flanks **42**.

[0039] All the liquid channels can be of identical configuration with regard to the above-described embodiment.

[0040] The following is provided with regard to the brazing materials which are present in FIGS. **1**, **2** and **3**: a copper brazing material **3***b*, indicated in FIG. **1** merely by way of some thick, arcuate lines which lie on the corrugation peaks **4***bg*, is situated on the visible upper side on the corrugations of the channel plates **4***a*. By way of this, the brazed connection is produced with the plate **1** (not shown) which lies on the channel **2***a*. The copper brazing material **3***b* for connecting to a bottom of the heat exchanger plate **1** which is shown is also situated on the non-visible underside of the channel plates **4***a*. The copper brazing material **3***b* on the underside has to be situated on the planar areas which lie on the bottom of the heat exchanger plate **1** and which can also be understood to be corrugation troughs **4***t*.

[0041] In contrast, an iron brazing material **3***a*, indicated merely by way of a single oval in FIG. **1** and by way of some lines in FIG. **3**, is situated on the upper side and on the underside of the slat **4***b* and on its corrugation peaks **4***bg* and corrugation troughs **4***t*. Said embodiment applies to the upper channel **2***a* which is shown and to the lower channel **2***a* which is not shown.

[0042] In contrast, exclusively the iron brazing material **3***a* is situated in all remaining channels **2***a* which are assigned to the cooling liquid.

[0043] In one exemplary embodiment which is not shown, not only is the uppermost channel **2***a* configured as described with regard to the brazing materials **3***a*, **3***b*, but rather also the following liquid channel **2***a*.

[0044] FIGS. **1** to **3** have not shown the oil channels in detail. The oil channels might be provided completely with a slat **4***b* (shown in FIG. **3**) or might also be of some other configuration. Exclusively the copper brazing material **3***b* is situated therein in said exemplary embodiment, in order to withstand the high pressure on the oil side.

[0045] In FIG. **1**, two first part regions A have also been marked which are arranged to the left and the right of a second part region B which corresponds to the abovementioned middle plate or channel region. The part regions A correspond to the likewise abovementioned inlet and outlet regions. In contrast to the above-described embodiment, according to which merely the upper or else also the next following liquid channel is configured with both brazing materials **3***a*, **3***b*, all the liquid channels of the heat exchanger are configured with the one and with the other brazing material **3***a*, **3***b* in the alternative embodiment. The copper brazing material **3***b* is therefore situated in the two part regions A and the iron brazing material **3***a* is situated in the second part region B. Exclusively the copper brazing material **3***b* is also situated in all the oil channels here.

[0046] FIG. **4** shows the oil channels there in somewhat greater detail. They are situated within tubes which are formed in this exemplary embodiment from pairs of plates **1** which are connected at their plate edges **10***b* and which therefore produce in each case one closed channel (first channel **2***a*). In contrast to the first exemplary embodiment, said plates **1** have merely two openings. In each case one open channel (second channel **2***b*) is situated between the tubes. The housing G which is present in said exemplary embodiment and in which the stack according to FIG. **4** is situated has been indicated in a similar manner to a frame. The open channels are flowed through by a cooling liquid which enters into the housing G and leaves the housing G again after having flowed through the open channels. The cooling liquid has been symbolized by way of block arrows and the oil by way of dashed arrows in FIG. **4**.

[0047] Exclusively a copper brazing material **3***b* is also situated within the oil channels in said exemplary embodiment.

[0048] In each case two other channel plates **4***c* are situated in the open channels. In contrast to the first exemplary embodiment, the said other channel plates **4***c* have merely a single opening. They are also of corrugated configuration, however, in order that they can be flowed through just like the channel plates **4***a* of the first exemplary embodiment. The opening corresponds with one of the abovementioned two plate openings. A copper brazing material **3***b* is situated in the upper, open channel which is shown, whereas an iron brazing material **3***a* is situated in the remaining other open channels which are not shown in detail. In FIG. **4**, the copper brazing material **3***b* has been shown as a brazing film, without being restricted hereto. It might also be, for example, a brazing paste or a brazing coating. The brazing film has been provided with cutouts, in order that the brazing material **3***b* is present only where it is required, for example in order to connect two lobes **11** which lie opposite one another and are configured in the plates **1**, and which in each case protrude into the open channels.

[0049] Various alternatives to the certain features and elements of the present invention are described with reference to specific embodiments of the present invention. With the exception of features, elements, and manners of operation that are mutually exclusive of or are inconsistent with each embodiment described above, it should be noted that the alternative features, elements, and manners of operation described with reference to one particular embodiment are applicable to the other embodiments.

[0050] The embodiments described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes in the elements and their configuration and arrangement are possible without departing from the spirit and scope of the present invention.

What is claimed is:

1. A brazed heat exchanger, comprising:
- a plurality of stacked plates defining a plurality of first channels for a first liquid and a plurality of second channels for a second liquid alternating in a plate stack direction;
- a first brazing material providing brazed connection seams in each one of the plurality of first channels; and
- a second brazing material different from the first brazing material providing brazed connection seams in at least some of the plurality of second channels, wherein at least one of the plurality of second channels has brazed connection seams provided by the first brazing material.

2. The brazed heat exchanger of claim **1**, wherein said at least one of the plurality of second channels additionally has brazed connection seams provided by the second brazing material.

3. The brazed heat exchanger of claim **2**, wherein said at least one of the plurality of second channels includes an inlet region for at least one of the fluids arranged at one end thereof, an outlet region for at least one of the fluids arranged at an opposing end thereof, and a central region between the inlet region and the outlet region, wherein brazed connection seams in the inlet and outlet regions are provided by the first brazing material and brazed connection seams in the central region are provided by the second brazing material.

4. The brazed heat exchanger of claim **1**, wherein the second brazing material provides brazed connection seams in each one of the plurality of second channels.

5. The brazed heat exchanger of claim **1**, wherein said at least one of the plurality of second channels includes an uppermost or a lowermost one of the plurality of second channels in the plate stack direction.

6. The brazed heat exchanger of claim **1**, wherein said at least one of the plurality of second channels includes both an uppermost and a lowermost one of the plurality of second channels in the plate stack direction.

7. The brazed heat exchanger of claim **1**, wherein the brazed connection seams in at least all of the plurality of second channels other than the uppermost two second channels and the lowermost two second channels are provided exclusively by the second brazing material.

8. The brazed heat exchanger of claim **7**, wherein the brazed connection seams in at least all of the plurality of second channels other than the uppermost second channel and the lowermost second channel are provided exclusively by the second brazing material.

9. The brazed heat exchanger of claim **1**, further comprising:
- a first and a second corrugated channel plate arranged within one of the at least one of the plurality of second channels that has brazed connection seams provided by the first brazing material; and
- a corrugated slat arranged within said channel between the first and second corrugated channel plates.

10. The brazed heat exchanger of claim **9**, wherein the first and second corrugated channel plates are joined to those ones of the plurality of stacked plates defining said channel by brazed connection seams provided by the first brazing material, and wherein the corrugated slat is joined to those ones of the plurality of stacked plates defining said channel by brazed connection seams provided by the second brazing material.

11. The brazed heat exchanger of claim **1**, wherein the first brazing material is a copper brazing material and wherein the second brazing material is an iron brazing material.

12. A brazed heat exchanger, comprising:
- a first plate;
- a second plate joined to the first plate by connected plate edges to form a first closed channel;
- a first part region of the first closed channel in which a first brazing material is arranged and a second part region of the first closed channel in which a second brazing material different from the first brazing material is arranged;
- a third plate joined to the second plate by connected plate edges to form a second closed channel, wherein the first brazing material but not the second brazing material is arranged in the second close channel; and
- a fourth plate joined to the third plate by connected plate edges to form a third closed channel, wherein the second brazing material but not the first brazing material is arranged in the second closed channel.

13. The brazed heat exchanger of claim **12**, further comprising:
- a first inlet channel and a first outlet channel extending through the first, second, third, and fourth plates, wherein a cooling liquid is fed to the first and the third closed channels by the first inlet channel; and
- a second inlet channel and a second outlet channel extending through the first, second, third, and fourth plates, wherein an oil is fed to the second closed channel by the second inlet channel.

14. The brazed heat exchanger of claim **13**, wherein the first and second inlet and outlet channels are arranged within the first part region of the first closed channel.

15. The brazed heat exchanger of claim **12**, wherein the second part region of the first closed channel is a middle region of the first flow channel.

16. The brazed heat exchanger of claim **12**, wherein the second, third, and fourth plates are trough-shaped plates that are stacked inside one another and wherein the first plate is a base plate or a cover plate.

17. A method of producing a brazed heat exchanger, comprising:
- assembling a plurality of heat exchanger parts into a stack to provide a set of first flow channels and a set of second flow channels in alternating sequence through the stack;

arranging a plurality of first corrugated slats within the set of first flow channels;

providing a first brazing material between peaks and troughs of the plurality of first corrugated slats and surfaces of the heat exchanger parts;

arranging a plurality of second corrugated slats within the set of second flow channels;

providing a second brazing material different from the first brazing material between peaks and troughs of the plurality of second corrugated slats and surfaces of the heat exchanger parts;

arranging a plurality of corrugated plates within the set of second flow channels;

providing a brazing material between surfaces of the plurality of corrugated plates and surfaces of the heat exchanger parts, wherein that brazing material is the first brazing material in one or more of the second flow channels; and

heating the stack to a temperature sufficient to melt both the first and the second brazing materials.

18. The method of claim **17**, wherein the first brazing material is a copper brazing material and wherein the second brazing material is an iron brazing material.

19. The method of claim **17**, wherein the plurality of corrugated plates are arranged in inlet and outlet regions of the set of second flow channels.

20. The method of claim **17**, further comprising:

assembling a base plate at one end of the stack of heat exchanger parts; and

assembling a cover plate at another end of the stack of heat exchanger parts opposite the one end, wherein one of the one or more second flow channels having the first brazing material between surfaces of the plurality of corrugated plates and surfaces of the heat exchanger parts is the second flow channel nearest either the base plate or the cover plate.

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