A fin (9) includes a perforated and/or recessed corrugated product which has a main direction of corrugation (F1) and which is bounded by two lateral edges (13). The main direction of corrugation (F1) is oblique with respect to the two lateral edges (13). The fin is useful in the main heat-exchange lines of air distillation plants.
HEAT-EXCHANGE FIN FOR A BRAZED-PLATE HEAT EXCHANGER, AND CORRESPONDING HEAT EXCHANGER

[0001] The present invention relates to a heat-exchange fin for a brazed-plate heat exchanger, of the type comprising a perforated and/or recessed corrugated product which has a main direction of corrugation and which is bounded by two lateral edges.

[0002] The invention applies, for example, to the main heat-exchange lines of air distillation plants, which bring the incoming air and the cold products resulting from the air distillation column into heat-exchange relationship.

[0003] Brazed-plate heat exchangers are widely used as they offer a large heat-exchange area in a particularly compact volume and, in addition, they are relatively easy to manufacture.

[0004] These exchangers, often made of aluminium or aluminium alloy, consist of a plurality of parallel, generally rectangular, plates between which are placed, on the one hand, spacer waves or fins of varied geometry and, on the other hand, bars for closing off the flat-shaped fluid flow passages bounded by the plates. The flows may be counter-current, co-current or crossed-current flows.

[0005] The function of the fins is to increase the heat-exchange area and therefore the overall heat transfer performance. Specifically, they transfer heat fluxes by conduction to the adjacent plates to which they are fastened by brazing.

[0006] The fins are produced very inexpensively from a folded, perforated, recessed and/or stamped flat product. The basic wave may have an approximately square, rectangular or triangular cross section. Basically, the known fins are called “straight waves”, which are a simple corrugated sheet, “perforated waves”, “herringbone waves”, having corrugated generatrices, “louvered waves”, the wave legs of which have recesses, and “serrated waves” or “partially offset waves” in which a transverse offset of the wave is produced at regular intervals along the generatrices, this offset generally being a wave half-period.

[0007] In all these known fins, the main direction of corrugation, which is the mean direction of corrugation in the case of herringbone waves, defines the direction of least resistance to the flow of the fluid.

[0008] In each passage of the exchanger, a main part of the length of the passage constitutes the actual heat-exchange part, which is fitted with a fin called a heat-exchange fin. In certain cases, this part is bordered by fluid inlet and outlet distribution parts fitted with distribution fins.

[0009] The heat-exchange part is bounded by two lateral closure bars parallel to two opposed sides of the plates, and the main direction of corrugation of the heat-exchange fin is parallel to these closure bars, with the exception sometimes of limited regions in which this main direction is perpendicular to the lateral closure bars (so-called “hard-way” arrangement) in order to create a local pressure drop. In the description which follows, hard-way fins will be ignored.

[0010] In the distribution parts, the fins have a general direction of corrugation which is highly inclined to that of the heat-exchange fins.

[0011] It is an object of the invention to increase the compactness of brazed-plate heat exchangers by improving their thermal performance.

[0012] For this purpose, the subject of the invention is a heat-exchange fin of the aforementioned type, characterized in that the main direction of corrugation is oblique with respect to the two lateral edges, and in that the fin has an overall direction of least resistance to the flow of a fluid which is approximately parallel to the two lateral edges.

[0013] The subject of the invention is also a brazed-plate heat exchanger of the type comprising a plurality of parallel rectangular plates which between them define passages of flat overall shape and, in each passage, a heat-exchange fin, each fin forming a spacer between two plates, together with lateral closure bars, and in which exchanger a heat-exchange fin is as defined above.

[0014] Illustrative examples of the invention will now be described with reference to the appended drawings in which:

[0015] FIG. 1 shows, in perspective, with partial cutaways, a brazed-plate heat exchanger according to the invention;

[0016] FIG. 2 shows a passage in this heat exchanger;

[0017] FIG. 3 shows, in perspective, part of a fin according to the invention;

[0018] FIG. 4 shows the same fin, taken in cross section on the mid-plane IV of FIG. 3;

[0019] FIGS. 5 and 7 show, in perspective, two other embodiments of the fin of the invention; and

[0020] FIGS. 6 and 8 show the fins of 5 and 7 in cross section in the mid-planes VI of FIG. 5 and VIII of FIG. 7, respectively.

[0021] The heat exchanger 1 shown in FIG. 1 is, for example, a cryogenic heat exchanger. It consists of a stack of parallel rectangular plates 2 which are all identical and between them define a plurality of passages for fluids to be brought into indirect heat-exchange relationship. In the example shown, these passages are, in succession and cyclically, passages 3 for a first fluid, passages 4 for a second fluid and passages 5 for a third fluid.

[0022] Each passage 3 to 5 is bordered by lateral closure bars 6 and end closure bars 7 which define the passage, leaving inlet/outlet windows 8 of the corresponding fluid free. Placed in each passage are spacer waves or corrugated fins which serve as thermal fins, as spacers between the plates, especially during brazing and in order to avoid any deformation of the plates when pressurized fluids are used, and as a means of guiding the fluid flows. These fins are, over essentially the entire length of the passage, heat-exchange fins 9. In their regions adjacent to the windows, these fins 9 are extended by distribution fins 10. The latter distribute the incoming fluid from an inlet window over the entire width of the fin 9, or collect the fluid coming off this entire width into an outlet window.

[0023] The stack of plates, closure bars and spacer waves is generally made of aluminium or aluminium alloy and is assembled in a single operation by oven brazing.

[0024] Fluid inlet/outlet boxes 11, of semicylindrical overall shape, are then welded to the exchanger body thus
produced so as to sit over the rows of corresponding inlet/outlet windows 8, these boxes 11 being connected to fluid feed and discharge pipes 12.

[0025] FIG. 2 shows schematically one of the passages in the same exchanger, namely a passage 3. The heat-exchange fin 9 has a main direction of corrugation F1 which makes a positive acute angle \( \alpha \), typically between 1° and 30° and preferably between 2° and 10°, with the longitudinal direction F2 of the passage, which is that of the lateral closure bars 6.

[0026] However, the arrangement of the fin 9 is such that the overall direction of least resistance to the flow in the passage remains approximately the direction F2.

[0027] Moreover, FIG. 2 shows the two distribution fins 10 adjacent to the inlet/outlet windows 8 of the passage. The angle \( \beta \) that the corrugations of these distribution fins make with the direction F2 is very much greater than the angle \( \alpha \) and typically close to 75°, and their overall direction of least resistance to the flow is their main direction of corrugation, so that they can fulfill their distributing function.

[0028] The fin 9 is made from a folded sheet material, the longitudinal direction of which is perpendicular to F1. This material is, after folding, cut to length along two lines 13 parallel to the direction F2, thereby resulting in several wave sheets 14, numbering three in FIG. 2, in the form of a parallelogram (in the case of the intermediate sheet or sheets) or in the form of a rectangular trapezium or a right-angled triangle (in the case of the two end sheets).

[0029] FIGS. 3 to 8 show three different embodiments of the fin 9.

[0030] In the embodiment in FIGS. 3 and 4, the fin comprises a corrugation of rectangular cross section, with wave troughs 15 and wave crests 16 joined together by wave legs 17.

[0031] Each leg 17 is provided, at regular intervals, with openings 18 pushed back on that side of the leg which receives the fluid flux (the left-hand side in FIGS. 3 and 4), which openings are open towards the upstream of this flux. Thus, as shown by arrows in FIG. 4, a stream of fluid guided in the direction F1 between two legs 17 is partially deflected transversely to this direction by the opening 18.

[0032] Thus, overall, the direction of least resistance to the flow of the fin 9 is approximately the direction F2 when the shape and the dimensions of the openings 18 are chosen appropriately. In addition, the inclination F1 and the openings 18 give the flow a two-dimensional and turbulent configuration which is conducive to efficient heat exchange.

[0033] In the embodiment in FIGS. 5 and 6, the fin is of the "serrated" type. It thus comprises, at regular intervals along the direction F1 called the "serration length" 1, a lateral offset d, alternately on one side and the other, which is generally equal to one half of the distance which separates two legs 17, called the "separation period" p. In this way, the fin has parallel offset planes P which, seen from above (FIG. 4), are parallel offset lines 19.

[0034] Each individual leg 17 has its leading edge bent through a right angle over its entire height, thereby defining a deflection tab 20. All the tabs 20 are oriented on the same side, namely on that side of the legs 17 which receives the fluid flow.

[0035] The tabs 20 have the effect of reducing the flow area for the fluid on that side where they are provided and of increasing this flow area on the opposite side. Thus, as FIG. 6 shows, each stream of fluid guided between two legs 17 sees its flow favoured in a direction close to F2, or even an oblique direction in the opposite sense to F1 with respect to F2.

[0036] On account of the turbulence generated in the fluid, the fin 9 has overall, as previously, a direction of least resistance to the flow close to F2, by means of a suitable choice of the parameters of the fin and of the dimensions of the tabs 20.

[0037] The embodiment in FIGS. 7 and 8 differs from the previous one by the omission of the tabs 20 and by the presence of indentations 21 over the entire height of certain leading edges and of certain trailing edges of the legs 17. More specifically:

[0038] in every other row of legs 17, the latter have, alternately, an indentation on both their leading edge and their trailing edge, and no indentation;

[0039] in the intermediate rows, the legs 17 have, alternately, an indentation 21 on their leading edge and an indentation on their trailing edge.

[0040] The resulting effect is substantially the same as that described above with regard to FIGS. 5 and 6.

1. Heat-exchange fin for a brazed-plate heat exchanger, of the type comprising a perforated and/or recessed corrugated product which has a main direction of corrugation (F1) and which is bounded by two lateral edges (13), characterized in that the main direction of corrugation (F1) is oblique with respect to the two lateral edges (13).

2. Fin according to claim 1, characterized in that it has an overall direction (F2) of least resistance to the flow of a fluid which makes a substantial angle with the main direction of corrugation (F1).

3. Fin according to claim 2, characterized in that the overall direction (F2) of least resistance to the flow of a fluid is approximately parallel to the two lateral edges (13).

4. Fin according to either of claims 2 and 3, characterized in that it includes, on its wave legs (17), features (18, 20, 21) which favour movement of the fluid transversely to the overall direction (F2) of least resistance to the flow.

5. Fin according to one of claims 1 to 4, characterized in that it includes, on its wave legs (17), features (18, 20, 21) for creating turbulence in the fluid.

6. Fin according to claim 4 or 5, characterized in that the features (18) consist of openings provided on that side of the wave legs (17) which receives the fluid flow, these openings being open towards the upstream of this flow.

7. Fin according to claim 4 or 5, of the serrated type, characterized in that the features consist of tabs (20) projecting on that side of the wave legs (17) which receives the fluid flow.

8. Fin according to claim 7, characterized in that the tabs (20) are provided on the leading edge of the wave legs (17).

9. Fin according to claim 4 or 5, of the serrated type, characterized in that the features consist of indentations (21) on the leading edges and/or trailing edges of the wave legs (17), these indentations being provided on the offset lines (19) of the fin (9) so as to increase the flow area for the fluid.
in a direction which, compared with the main direction of corrugation (F1), approaches the direction (F2) of the said lateral edges (13).

10. Brazed-plate heat exchanger of the type comprising a plurality of parallel rectangular plates (2) which between them define passages (3, 4, 5) of flat overall shape and, in each passage, a heat-exchange fin (9), each fin forming a spacer between two plates, together with lateral closure bars (6), characterized in that at least one heat-exchange fin (9) is in accordance with any one of claims 1 to 9.

11. Heat exchanger according to claim 10, characterized in that it constitutes a main heat-exchange line of an air distillation plant.

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