(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 141 858 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
15.03.2017 Bulletin 2017/11

(21) Application number: **15788925.4**

(22) Date of filing: **06.05.2015**

(51) Int Cl.:
F28D 1/053 *(2006.01)*

(86) International application number:
PCT/CN2015/078406

(87) International publication number:
WO 2015/169231 (12.11.2015 Gazette 2015/45)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(30) Priority: **06.05.2014 CN 201410188198**

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(54) BENDED HEAT EXCHANGER

(57) Disclosed is a bended heat exchanger (10), which comprises: a first collecting pipe (101) and a second collecting pipe (102); a plurality of flat pipes (103), which have two ends thereof respectively connected with the first collecting pipe (101) and the second collecting pipe (102) and which are arranged spaced apart from each other along the axial directions thereof; and fins (104) which are arranged between adjacent flat pipes (103) and extend in a corrugated manner along the length direction of the flat pipes (103), the thickness of the fin (104) being FT; in the first and the second collecting pipes (101, 102), the larger external diameter is OD, and the larger wall thickness is T; the width of the flat pipes (103) is W, the arc radius of the fin (104) is FR, the height of the fin (104) is FH, and $0.01 \leq (100 \times FT \times FR \times T)/(FH \times OD) \leq 9$.

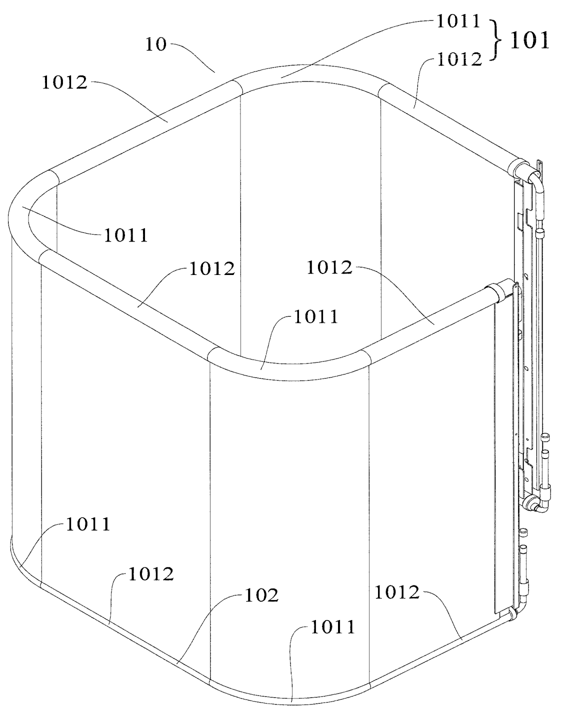

Fig. 1

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Description

FIELD

[0001] The present disclosure relates to a heat exchanger, and more particularly to a bent parallel-flow heat exchanger.

BACKGROUND

[0002] A heat exchanger, for example a parallel-flow heat exchanger (such as a multi-channel heat exchanger), is broadly applied to a refrigeration system, and in some application situations, the heat exchanger needs to be bent, that is, a header of the heat exchanger needs to be bent. However, when the heat exchanger is bent along a length direction of the header, if bent improperly, a performance of the heat exchanger will be affected adversely, or application requirements cannot be met. Thus, there exists a demand for improving the bent heat exchanger.

SUMMARY

[0003] Based on following facts and problems discovered by inventors, the present disclosure is made.

[0004] When a heat exchanger is bent along a length direction of a header, if a bending radius is oversize, application requirements cannot be met in a case that a mounting space for the heat exchanger is limited. If the bending radius is undersize, a flat tube of the heat exchanger is deformed and a fin of the heat exchanger is torn, such that a heat exchange efficiency is affected, thus reducing a performance, even leading to a leakage of the flat tube and causing the heat exchanger to be scrapped. In addition, an excessive compression and deformation of the header may increase a pressure loss of coolant in the header and thus reduce the performance of the heat exchanger. Therefore, inventors realize that, a control of bending parameters is a factor affecting the performance, reliability and mounting-application convenience of the bent heat exchanger.

[0005] For that reason, an objective of the present disclosure is to provide a bent heat exchanger. Through a structural parameter design of the header, the flat tube and the fin, the bending radius of the header is controlled, such that when the heat exchanger is bent along the header, the fin at an outer side of the bending will not be torn, and the header after being bent has a reduced deformation and an enough bursting strength.

[0006] The bent heat exchanger according to some embodiments of the present disclosure includes: a first header and a second header, each of the first header and the second header including at least one bent segment and a straight segment adjoining the bent segment, the bent segment of the first header being corresponding to the bent segment of the second header; a plurality of flat tubes, two ends of the flat tube being connected to the first header and the second header respectively, the plurality of flat tubes being spaced apart from one another along axial directions of the first header and the second header; and fins, each disposed between adjacent flat tubes, extending in a corrugated shape along a length direction of the flat tube, and including flat-straight segments and arc segments, each arc segment being connected between adjacent flat-straight segments. A thickness of the fin is denoted as FT, the first header and the second header have different outer diameters, in which a larger one of the outer diameters of the first header and the second header is denoted as OD, the first header and the second header have different wall thicknesses, in which a larger one of the wall thicknesses of the first header and the second header is denoted as T, a width of the flat tube is denoted as W, an arc radius of the fin is denoted as FR, and a height of the fin is denoted as FH, in which $0.01 \leq (100 \times FT \times FR \times T)/(FH \times OD) \leq 9$.

[0007] The bent heat exchanger according to some other embodiments of the present disclosure includes: a first header and a second header, each of the first header and the second header including at least one bent segment and a straight segment adjoining the bent segment, the bent segment of the first header being corresponding to the bent segment of the second header; a plurality of flat tubes, two ends of the flat tube being connected to the first header and the second header respectively, the plurality of flat tubes being spaced apart from one another along axial directions of the first header and the second header; and a fin disposed between adjacent flat tubes, extending in a corrugated shape along a length direction of the flat tube, and including a plurality of flat-straight segments and an arc segment connected between the flat-straight segments. A thickness of the fin is denoted as FT, the first header and the second header have an equal outer diameter and both outer diameters of the first header and the second header are donated as OD, the first header and the second header have an equal wall thickness and both wall thicknesses of the first header and the second header are donated as T, a width of the flat tube is denoted as W, an arc radius of the fin is denoted as FR, and a height of the fin is denoted as FH, in which $0.01 \leq (100 \times FT \times FR \times T)/(FH \times OD) \leq 9$.

[0008] The thickness FT of the fin, the arc radius FR of a top of the fin and the height FH of the fin may cause an apparent tensile stress for the stretch of the fin during bending. The tensile stress is denoted as Sfin. When the tensile stress Sfin is larger than a yield strength σs of a welded joint of the fin and the flat tube, the fin tends to be separated from the flat tube, and even to be fractured. On the other hand, the wall thickness T and the outer diameter OD of the header may cause an apparent bending stress during bending. The bending stress is denoted as Shd. When the bending stress Shd is larger than a tensile strength σb of the header, the header will have a failure, and will have the failure under a certain pressure.

[0009] By tests under conditions of different bending radiuses, it is found that, under the application conditions of different bending radiuses R, a certain change relationship exists between a relative stress Sfin/σs on the fin, as well as a relative tensile stress Shd/σb on the header, and a recombination parameter (100×FT×FR×T)/(FH×OD) of the fin and the header. The relative stress Sfin/σs on the fin decreases along with the increasing of the recombination parameter, and rises rapidly when the recombination parameter decreases and approaches to zero. Further, the relative stress Sfin/σs on the fin generally decreases along with the rising of the bending radius R. The relative tensile stress Shd/σb on the header, along with the increasing of the recombination parameter, firstly decreases (the strength of the header is not enough when the wall thickness of the header is relatively small), and then rises gradually (a bending deformation stress rises when the relative wall thickness of the header is relatively large).

[0010] During an actual bending procedure, a bending radius of a traditional copper-tube and fin heat exchanger of an air conditioner generally is more than R50 mm. According to a condition that the relative stress Sfin/σs and the relative tensile stress Shd/σb should be lower than 1, so as to ensure that the bending intensity will not cause a failure, a lower limit and an upper limit of the recombination parameter (100×FT×FR×T)/(FH×OD) are respectively determined as 0.01 and 9. Through the determination of such scope, when the header is bent, an apparent tension fracture of the fin and a deformation failure or a bursting failure of the header will not come about in a micro-channel heat exchanger.

[0011] When a relation 0.01≤(100×FT×FR×T)/(FH×OD)≤9 is met, after the bent heat exchanger is bent along the length directions of the first header and the second header, it not only may be ensured that the fin is not torn and the flat tube is not deformed, but also may be ensured that the coil has an enough bursting strength. In addition, a change of a heat exchange performance of the bent heat exchanger may be limited within 4% (compared to the bent heat exchanger before being bent), an apparent unbalanced charging will not come about, and a drainage performance of the bent heat exchanger for the condensed water is optimal as well.

[0012] Therefore, the bent heat exchanger according to embodiments of the present disclosure has advantages of a reasonable structure, a steady construction, a high heat exchange efficiency, a great heat exchange performance, a high reliability, an easy mounting and application, and a great drainage performance.

[0013] In addition, the bent heat exchanger according to the above embodiments of the present disclosure may further include following additional technical features.

[0014] According to an embodiment of the present disclosure, 0.0004≤(FT×FR)/(FH×OD)≤0.59. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0015] According to an embodiment of the present disclosure, 0.02≤(FT×FR)/FH≤6. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0016] According to an embodiment of the present disclosure, 0.002≤FT/FH≤0.04. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0017] According to an embodiment of the present disclosure, 0.0061≤FR/FH≤0.6. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0018] According to an embodiment of the present disclosure, 0.04≤T/OD≤0.25. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0019] According to an embodiment of the present disclosure, 0.0005≤FT/OD≤0.015. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0020] According to an embodiment of the present disclosure, 0.0016≤FR/OD≤0.4. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0021] According to an embodiment of the present disclosure, 0.05≤FH/OD≤2. Thus, it is further ensured that the fin is not torn, the flat tube is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger are further improved.

[0022] According to an embodiment of the present disclosure, the bent heat exchanger is configured to be C-shaped or L-shaped.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Fig. 1 is a perspective view of a bent heat exchanger according to embodiments of the present disclosure;

Fig. 2 is a schematic view of a bent heat exchanger before being bent according to embodiments of the present disclosure;

Fig. 3 is a schematic view of a header after being bent of a bent heat exchanger according to embodiments of the present disclosure;

Fig. 4 is a schematic view of a header and a flat tube of a bent heat exchanger according to embodiments of the present disclosure;

Fig. 5 is a schematic view of a fin of a bent heat exchanger according to embodiments of the present disclosure;

Fig. 6 is a graph showing a relation curve between a relative stress on a fin, as well as relative tensile stresses on a first header and a second header, and a recombination parameter, under conditions of different bending radiuses.

DETAILED DESCRIPTION

[0024] Reference will be made in detail to embodiments of the present disclosure. The embodiments described herein with reference to drawings are explanatory, illustrative, and used to generally understand the present disclosure. The embodiments shall not be construed to limit the present disclosure.

[0025] A bent heat exchanger 10 according to embodiments of the present disclosure will be described with reference to Figs. 1-5 in the following. As shown in Figs. 1-5, the bent heat exchanger 10 according to embodiments of the present disclosure includes a first header 101, a second header 102, fins 104 and a plurality of flat tubes 103.

[0026] Each of the first header 101 and the second header 102 includes at least one bent segment 1011 and a straight segment 1012 adjoining the bent segment 1011. The bent segment 1011 of the first header 101 is corresponding to the bent segment 1011 of the second header 102. Two ends of the flat tube 103 are connected to the first header 101 and the second header 102 respectively, the plurality of flat tubes 103 are spaced apart from one another along axial directions of the first header 101 and the second header 102. Each fin 104 is disposed between adjacent flat tubes 103, and extends in a corrugated shape along a length direction of the flat tube 103. Each fin 104 includes flat-straight segments 1041 and arc segments 1042, and each arc segment 1042 is connected between adjacent flat-straight segments 1041.

[0027] A thickness of the fin 104 is denoted as FT, the first header 101 and the second header 102 may have different outer diameters, and a larger one of the outer diameters of the first header 101 and the second header 102 is denoted as OD. Optionally, the first header 101 and the second header 102 may have an equal outer diameter, and both the outer diameters of the first header 101 and the second header 102 are donated as OD.

[0028] The first header 101 and the second header 102 may have different wall thicknesses, and a larger one of the wall thicknesses of the first header 101 and the second header 102 is denoted as T. Optionally, the first header 101 and the second header 102 may have an equal wall thickness, and both the wall thicknesses of the first header 101 and the second header 102 are donated as T. A width of the flat tube 103 is denoted as W, an arc radius of the fin 104 is denoted as FR, and a height of the fin 104 is denoted as FH, in which $0.01 \leq (100\times FT\times FR\times T)/(FH\times OD) \leq 9$.

[0029] It can be understood that, as mentioned above, the first header 101 and the second header 102 may have an equal outer diameter OD, and may as well have different outer diameters. When the first header 101 and the second header 102 have different outer diameters, the larger one of the outer diameters of the first header 101 and the second header 102 is donated as OD. The first header 101 and the second header 102 may have an equal wall thickness T, and may as well have different wall thicknesses. When the first header 101 and the second header 102 have different wall thicknesses, the larger one of the wall thicknesses of the first header 101 and the second header 102 is denoted as T. Inventors of the present disclosure discover that, when the first header 101 and the second header 102 have different outer diameters and different wall thicknesses, the header having the larger outer diameter and/or the larger wall thickness is relatively difficult to be bent, and tends to be significantly influenced by bending. Certainly, in embodiments of the present disclosure, the first header 101 and the second header 102 may have an equal outer diameter and an equal wall thickness. When the first header 101 and the second header 102 have the equal outer diameter and/or the equal wall thickness, the outer diameter OD may be the outer diameter of any one of the first header 101 and the second header 102, and the wall thickness T may be the wall thickness of any one of the first header 101 and the second header 102.

[0030] Through deep research and creative work, inventors discover following things.

[0031] When a thickness (the width W of the flat tube 103) of a coil is determined, a decrease of a bending radius R will cause an overall bursting strength of the coil to be lowered, and therefore the wall thicknesses of the first header 101 and the second header 102 need to be increased (the outer diameters of the first header 101 and the second header 102 are not changed), or the outer diameters of the first header 101 and the second header 102 need to be decreased (the wall thicknesses of the first header 101 and the second header 102 are not changed), so as to meet strength requirements. However, increasing the wall thicknesses of the first header 101 and the second header 102, not only increases a cost, but also decreases internal volumes of the first header 101 and the second header 102. In addition, in a heat pump system having the bent heat exchanger 10 at an outdoor unit, there exists an apparent difference between an internal volume of an indoor unit and an internal volume of the outdoor unit, and the decreases of the internal volumes of the first header 101 and the second header 102 will make the unit have an unbalanced charging at a refrigerating condition and a heating condition.

[0032] On the other hand, in terms of design of the fin 104, after the first header 101 and the second header

102 are bent, an arc portion at a top of the fin 104 will be stretched after being bent, and therefore the larger the arc radius of the top of the fin 104 is, the more stretch thereof may be generated, thus bearing a larger bending stress and preventing a tear from being formed at a welding seam due to an excessive stretch of the fin 104. But, an oversize arc radius may cause condensed water to accumulate at the arc portion due to a surface tension effect thereof, and thus it is not easy for the condensed water to be discharged out of the fin 104. Moreover, increasing the arc radius of the top of the fin 104 may increase a risk of the fin 104 collapsing after being welded.

[0033] The strength of the fin 104 is in direct proportion to the thickness of the fin 104, a thicker fin 104 may resist a larger bending stress, and therefore it is not easy for the flat tube 103 after being bent to have a wavy deformation. But, increasing the thickness of the fin 104 not only results in an increased cost of the bent heat exchanger 10, but also causes an increased ventilation resistance, thus reducing a performance of the unit.

[0034] The height of the fin 104 will as well influence the bending performance, the larger the height of the fin 104 is, the larger a spacing between the flat tubes 103 is, and thus a support force to the first header 101 and the second header 102 within per unit length is smaller, such that it is easier for the first header 101 and the second header 102 is to be deformed after being bent. However, the smaller the height of the fin 104 is, the larger the ventilation resistance is.

[0035] The thickness FT of the fin 104, the arc radius FR of the top of the fin 104 and the height FH of the fin 104 may cause an apparent tensile stress for the stretch of the fin 104 during the bending. The tensile stress is denoted as Sfin. When the tensile stress Sfin is larger than a yield strength σs of a welded joint of the fin 104 and the flat tube 103, the fin 104 tends to be separated from the flat tube 103, and even to be fractured. On the other hand, the wall thicknesses T and the outer diameters OD of the first header 101 and the second header 102 may cause an apparent bending stress during the bending, and the bending stress is denoted as Shd. When the bending stress Shd is larger than a tensile strength σb of the first header 101 and the second header 102, the first header 101 and the second header 102 may have a failure, and may have the failure under a certain pressure.

[0036] By tests under conditions of different bending radiuses R, it is found that under the application conditions of different bending radiuses R, a certain change relationship exists between a relative stress Sfin/σs on the fin 104, as well as relative tensile stresses Shd/σb on the first header 101 and the second header 102, and a recombination parameter $(100\times FT\times FR\times T)/(FH\times OD)$ of the fin 104, the first header 101 and the second header 102. As shown in Fig. 6, the relative stress Sfin/σs on the fin 104 decreases along with the increasing of the recombination parameter, and rises rapidly when the recombination parameter decreases and approaches to zero. Further, the relative stress Sfin/σs on the fin 104 decreases generally along with the rising of the bending radius R. The relative tensile stresses Shd/σb on the first header 101 and the second header 102, along with the increasing of the recombination parameter, firstly decrease (the strength of the header is not enough when the wall thicknesses of the first header 101 and the second header 102 are relatively small), and then rise gradually (a bending deformation stress rises when the relative wall thickness of the first header 101 and the second header 102 is relatively large).

[0037] During an actual bending procedure, a bending radius of a traditional copper-tube and fin heat exchanger of an air conditioner is generally more than R50 mm. According to a condition that the relative stress Sfin/σs and the relative tensile stress Shd/σb should be lower than 1, so as to ensure that the bending intensity will not cause a failure, a lower limit and an upper limit of the recombination parameter $(100\times FT\times FR\times T)/(FH\times OD)$ are determined respectively as 0.01 and 9. Through the determination of such scope, when the first header 101 and the second header 102 are bent, an apparent tension fracture of the fin and a deformation failure or a bursting failure of the header will not come about in the bent heat exchanger 10.

[0038] By consideration of various factors, when the relation $0.01 \leq (100\times FT\times FR\times T)/(FH\times OD) \leq 9$ is met, after the bent heat exchanger 10 is bent along length directions of the first header 101 and the second header 102, it not only may be ensured that the fin 104 is not torn and the flat tube 103 is not deformed, but also may be ensured that the coil has an enough bursting strength. In addition, a change of a heat exchange performance of the bent heat exchanger 10 may be limited within 4% (compared to the bent heat exchanger 10 before being bent), the apparent unbalanced charging will not come about, and a drainage performance of the bent heat exchanger 10 for the condensed water is optimal as well.

[0039] Therefore, the bent heat exchanger 10 according to embodiments of the present disclosure has advantages of a reasonable structure, a steady construction, a high heat exchange efficiency, a great heat exchange performance, a high reliability, an easy mounting and application, and a great drainage performance.

[0040] More specifically, the axial directions of the first header 101 and the second header 102 may be the length directions of the first header 101 and the second header 102.

[0041] When a length unit for each of the thickness FT of the fin 104, the larger outer diameter OD of the outer diameters of the first header 101 and the second header 102, the larger wall thickness T of the wall thicknesses of the first header 101 and the second header 102, the width W of the flat tube 103, the arc radius FR of the fin 104 and the height FH of the fin 104 is millimeter, 0.01 mm $\leq (100\times FT\times FR\times T)/(FH\times OD) \leq$ 9mm, the same as below.

[0042] As shown in Fig. 1, in some embodiments of the present disclosure, the bent heat exchanger 10 may be configured to be C-shaped. In other words, the bent heat exchanger 10 may be bent three times along the length directions of the first header 101 and the second header 102. That is, each of the first header 101 and the second header 102 may include three bent segments 1011 and four straight segments 1012, and each bent segment 1011 is located between two adjacent straight segments 1012.

[0043] In addition, the bent heat exchanger 10 may also be configured to be L-shaped.

[0044] Preferably, $0.1 \leq (100\times FT\times FR\times T)/(FH\times OD) \leq 7$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0045] Further preferably, $0.5 \leq (100\times FT\times FR\times T)/(FH\times OD) \leq 5$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0046] Most preferably, $1 \leq (100\times FT\times FR\times T)/(FH\times OD) \leq 3$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0047] Advantageously, the thickness FT of the fin 104, the arc radius FR of the fin 104, the height FH of the fin 104, and the larger outer diameter OD of the outer diameters of the first header 101 and the second header 102 meet a following relation: $0.0004 \leq (FT\times FR)/(FH\times OD) \leq 0.59$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0048] Further advantageously, $0.004 \leq (FT\times FR)/(FH\times OD) \leq 0.3$. Most advantageously, $0.04 \leq (FT\times FR)/(FH\times OD) \leq 0.1$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0049] The thickness FT of the fin 104, the arc radius FR of the fin 104 and the height FH of the fin 104 may meet a following relation: $0.02 \leq (FT\times FR)/FH \leq 6$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0050] Preferably, $0.05 \leq (FT\times FR)/FH \leq 3$. Further preferably, $0.1 \leq (FT\times FR)/FH \leq 2$. Most preferably, $0.5 \leq (FT\times FR)/FH \leq 1$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0051] The thickness FT of the fin 104 and the height FH of the fin 104 may meet a following relation: $0.002 \leq FT/FH \leq 0.04$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0052] Advantageously, $0.005 \leq FT/FH \leq 0.01$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0053] The arc radius FR of the fin 104 and the height FH of the fin 104 may meet a following relation: $0.0061 \leq FR/FH \leq 0.6$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0054] Preferably, $0.01 \leq FR/FH \leq 0.3$. Further preferably, $0.05 \leq FR/FH \leq 0.1$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0055] The larger wall thickness T of the wall thicknesses of the first header 101 and the second header 102 and the larger outer diameter OD of the outer diameters of the first header 101 and the second header 102 may meet a following relation: $0.04 \leq T/OD \leq 0.25$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0056] Preferably, $0.1 \leq T/OD \leq 0.2$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0057] The thickness FT of the fin 104 and the larger outer diameter OD of the outer diameters of the first header 101 and the second header 102 may meet a following relation: $0.0005 \leq FT/OD \leq 0.015$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0058] Preferably, $0.001 \leq FT/OD \leq 0.01$. Further preferably, $0.003 \leq FT/OD \leq 0.007$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0059] The arc radius FR of the fin 104 and the larger outer diameter OD of the outer diameters of the first header 101 and the second header 102 meet a following relation: $0.0016 \leq FR/OD \leq 0.4$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0060] Preferably, $0.016 \leq FR/OD \leq 0.1$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0061] The height FH of the fin 104 and the larger outer diameter OD of the outer diameters of the first header 101 and the second header 102 may meet a following relation: $0.05 \leq FH/OD \leq 2$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0062] Preferably, $0.1 \leq FH/OD \leq 1$. Further preferably, $0.3 \leq FH/OD \leq 0.7$. Thus, it is further ensured that the fin 104 is not torn, the flat tube 103 is not deformed and the coil has the enough bursting strength. Also, the heat exchange efficiency and the drainage performance of the bent heat exchanger 10 are further improved.

[0063] In the specification, it is to be understood that terms such as "central," "longitudinal," "lateral," "length," "width," "thickness," "upper," "lower," "front," "rear," "left," "right," "vertical," "horizontal," "top," "bottom," "inner," "outer," "clockwise," and "counterclockwise" should be construed to refer to the orientation as then described or as shown in the drawings under discussion. These relative terms are for convenience of description and do not require that the present disclosure be constructed or operated in a particular orientation.

[0064] In addition, terms such as "first" and "second" are used herein for purposes of description and are not intended to indicate or imply relative importance or significance or to imply the number of indicated technical features. Thus, the feature defined with "first" and "second" may comprise one or more of this feature. In the description of the present disclosure, "a plurality of" means two or more than two, unless specified otherwise.

[0065] In the present disclosure, unless specified or limited otherwise, the terms "mounted," "connected," "coupled," "fixed" and the like are used broadly, and may be, for example, fixed connections, detachable connections, or integral connections; may also be mechanical or electrical connections; may also be direct connections or indirect connections via intervening structures; may also be inner communications of two elements, which can be understood by those skilled in the art according to specific situations.

[0066] In the present disclosure, unless specified or limited otherwise, a structure in which a first feature is "on" or "below" a second feature may include an embodiment in which the first feature is in direct contact with the second feature, and may also include an embodiment in which the first feature and the second feature are not in direct contact with each other, but are contacted via an additional feature formed therebetween. Furthermore, a first feature "on," "above," or "on top of" a second feature may include an embodiment in which the first feature is right or obliquely "on," "above," or "on top of" the second feature, or just means that the first feature is at a height higher than that of the second feature; while a first feature "below," "under," or "on bottom of" a second feature may include an embodiment in which the first feature is right or obliquely "below," "under," or "on bottom of" the second feature, or just means that the first feature is at a height lower than that of the second feature.

[0067] Reference throughout this specification to "an embodiment," "some embodiments," "one embodiment", "another example," "an example," "a specific example," or "some examples," means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. Thus, the appearances of the phrases such as "in some embodiments," "in one embodiment", "in an embodiment", "in another example," "in an example," "in a specific example," or "in some examples," in various places throughout this specification are not necessarily referring to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples.

[0068] Although explanatory embodiments have been shown and described, it would be appreciated by those skilled in the art that the above embodiments cannot be construed to limit the present disclosure, and changes, alternatives, and modifications can be made in the embodiments without departing from spirit, principles and scope of the present disclosure.

Claims

1. A bent heat exchanger, comprising:

a first header and a second header, each of the first header and the second header comprising at least one bent segment and a straight segment adjoining the bent segment, the bent segment of the first header being corresponding to the bent segment of the second header;

a plurality of flat tubes, two ends of the flat tube being connected to the first header and the second header respectively, the plurality of flat tubes being spaced apart from one another along axial directions of the first header and the second header; and

fins, each disposed between adjacent flat tubes, extending in a corrugated shape along a length direction of the flat tube, and comprising flat-straight segments and arc segments, each arc segment being connected between adjacent flat-straight segments,

wherein a thickness of the fin is denoted as FT, the first header and the second header have different outer diameters, in which a larger one of the outer diameters of the first header and the second header is denoted as OD, the first header and the second header have different wall thicknesses, in which a larger one of the wall thicknesses of the first header and the second header is denoted as T, a width of the flat tube is denoted as W, an arc radius of the fin is denoted as FR, and a height of the fin is denoted as FH,

wherein

$$0.01 \leq (100 \times FT \times FR \times T)/(FH \times OD) \leq 9.$$

2. A bent heat exchanger comprising:

a first header and a second header, each of the first header and the second header comprising at least one bent segment and a straight segment adjoining the bent segment, the bent segment of the first header being corresponding to the bent segment of the second header;

a plurality of flat tubes, two ends of the flat tube being connected to the first header and the second header respectively, the plurality of flat tubes being spaced apart from one another along axial directions of the first header and the second header; and

fins, each disposed between adjacent flat tubes, extending in a corrugated shape along a length direction of the flat tube, and comprising flat-straight segments and arc segments, each arc segment being connected between adjacent flat-straight segments,

wherein a thickness of the fin is denoted as FT, the first header and the second header have an equal outer diameter and both outer diameters of the first header and the second header are donated as OD, the first header and the second header have an equal wall thickness and both wall thicknesses of the first header and the second header are donated as T, a width of the flat tube is denoted as W, an arc radius of the fin is denoted as FR, and a height of the fin is denoted as FH,

wherein

$$0.01 \leq (100 \times FT \times FR \times T)/(FH \times OD) \leq 9.$$

3. The bent heat exchanger according to claim 1 or 2, wherein,

$$0.0004 \leq (FT \times FR)/(FH \times OD) \leq 0.59.$$

4. The bent heat exchanger according to any one of claims 1-3, wherein,

$$0.02 \leq (FT \times FR)/FH \leq 6.$$

5. The bent heat exchanger according to any one of claims 1-4, wherein,

$$0.002 \leq FT/FH \leq 0.04.$$

6. The bent heat exchanger according to any one of claims 1-5, wherein,

$$0.0061 \leq FR/FH \leq 0.6.$$

7. The bent heat exchanger according to any one of claims 1-6, wherein,

$$0.04 \leq T/OD \leq 0.25.$$

8. The bent heat exchanger according to any one of claims 1-7, wherein,

$$0.0005 \leq FT/OD \leq 0.015.$$

9. The bent heat exchanger according to any one of claims 1-8, wherein,

$$0.0016 \leq FR/OD \leq 0.4.$$

10. The bent heat exchanger according to any one of claims 1-9, wherein,

$$0.05 \leq FH/OD \leq 2.$$

11. The bent heat exchanger according to any one of claims 1-10, wherein the bent heat exchanger is configured to be C-shaped or L-shaped.

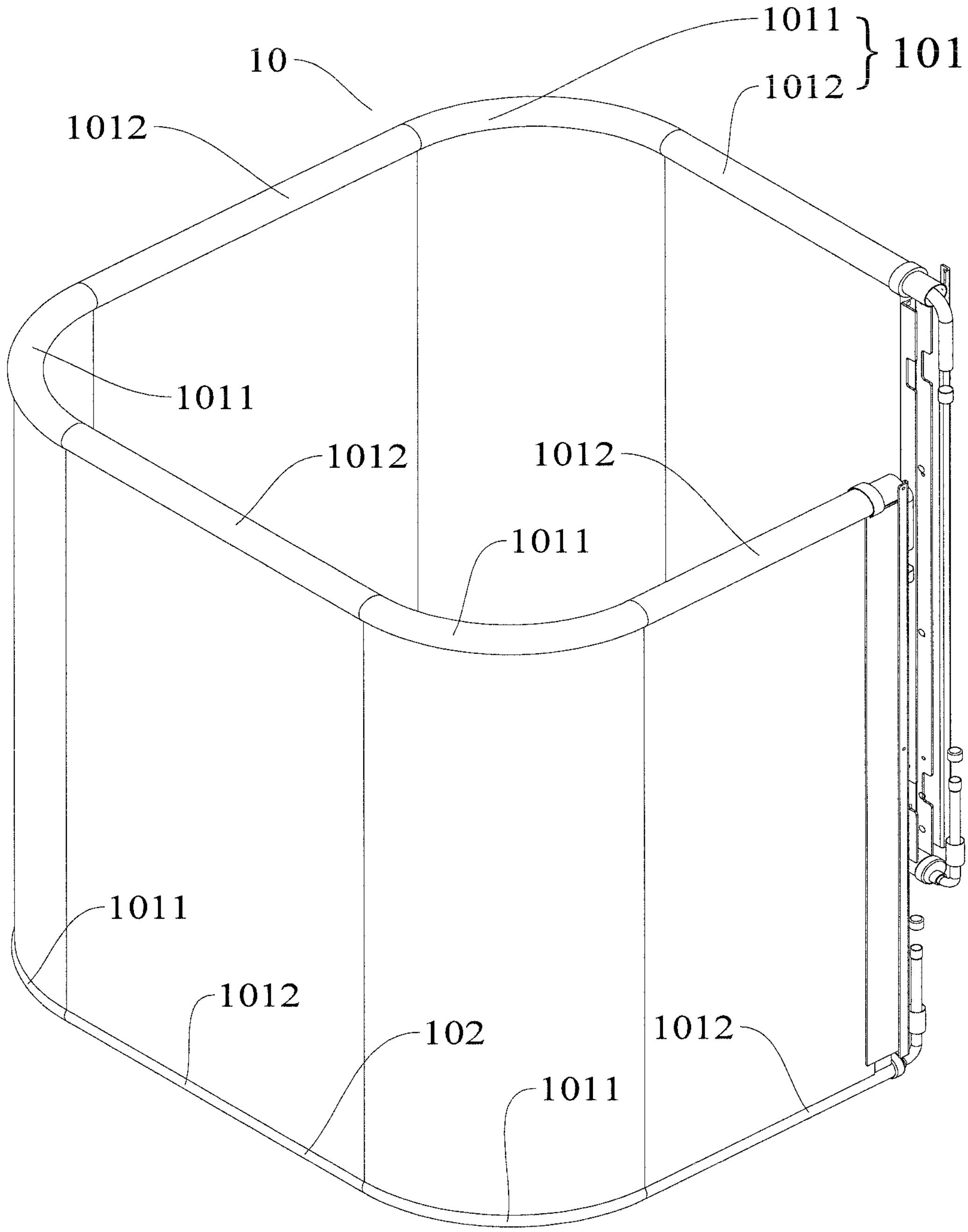
1011
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Fig. 1

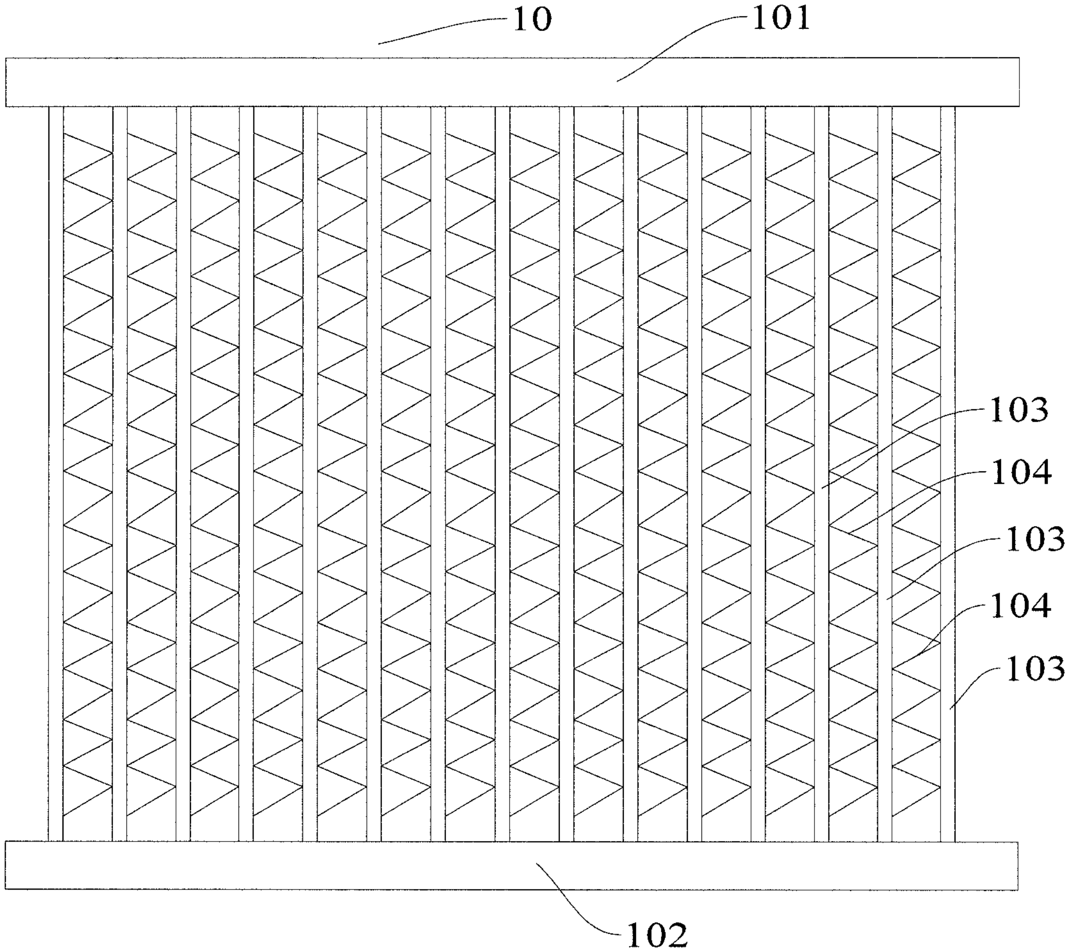

Fig. 2

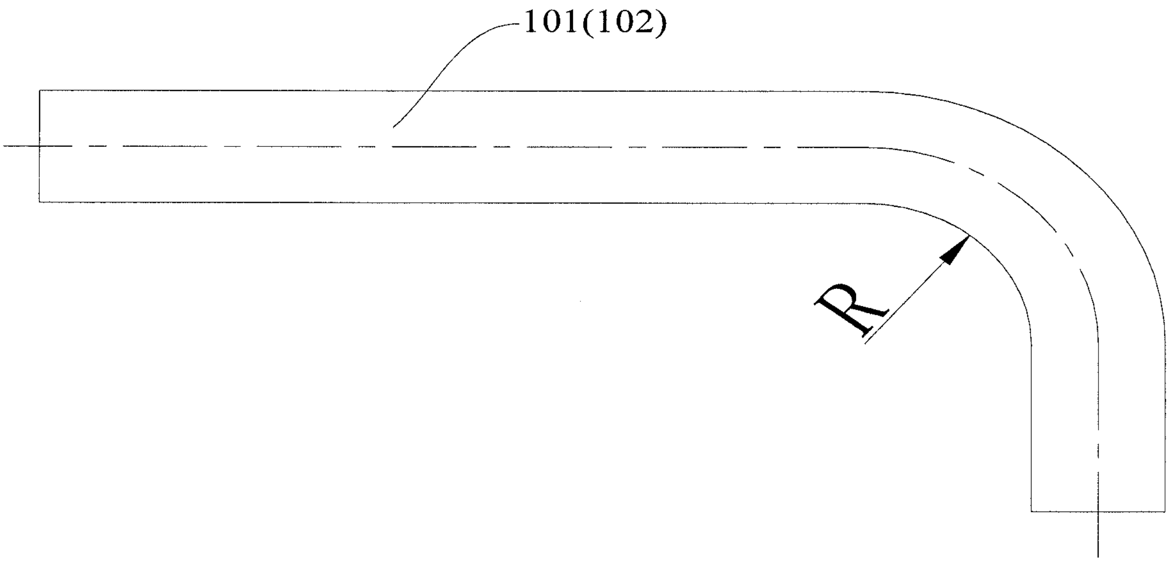

Fig. 3

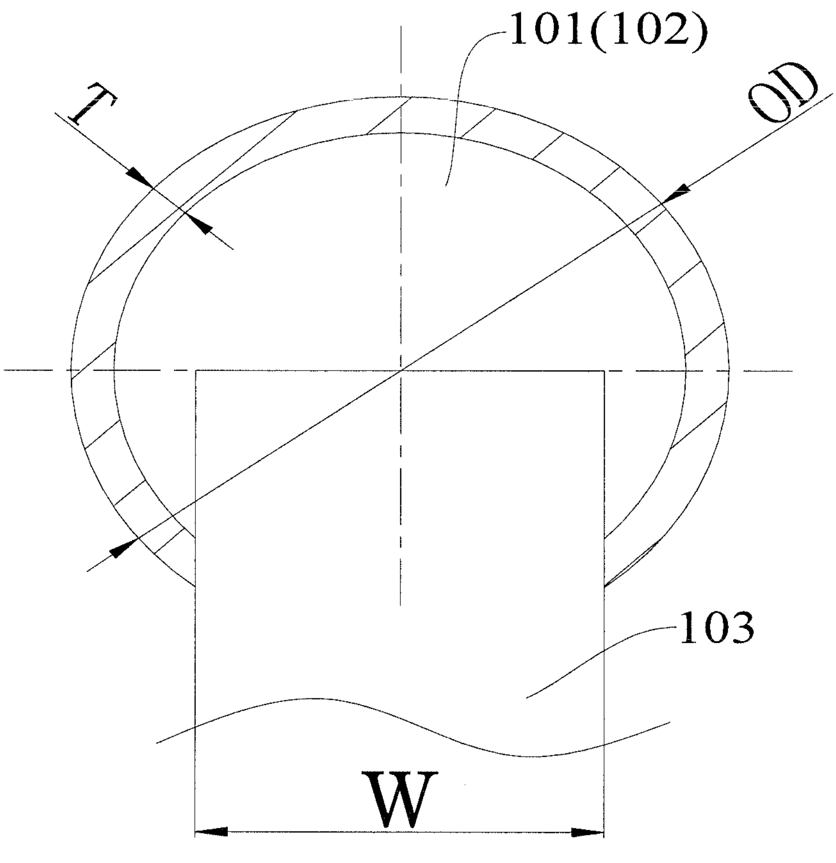

Fig. 4

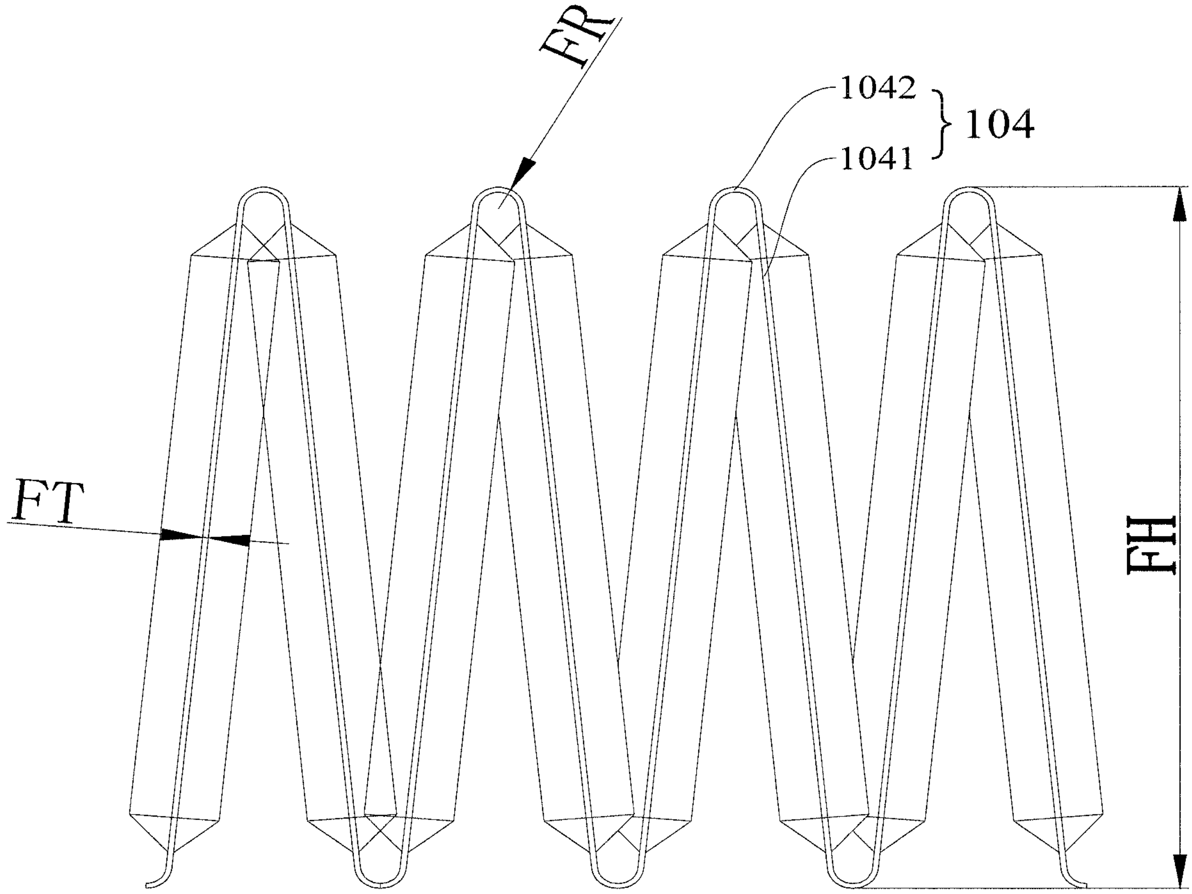

Fig. 5

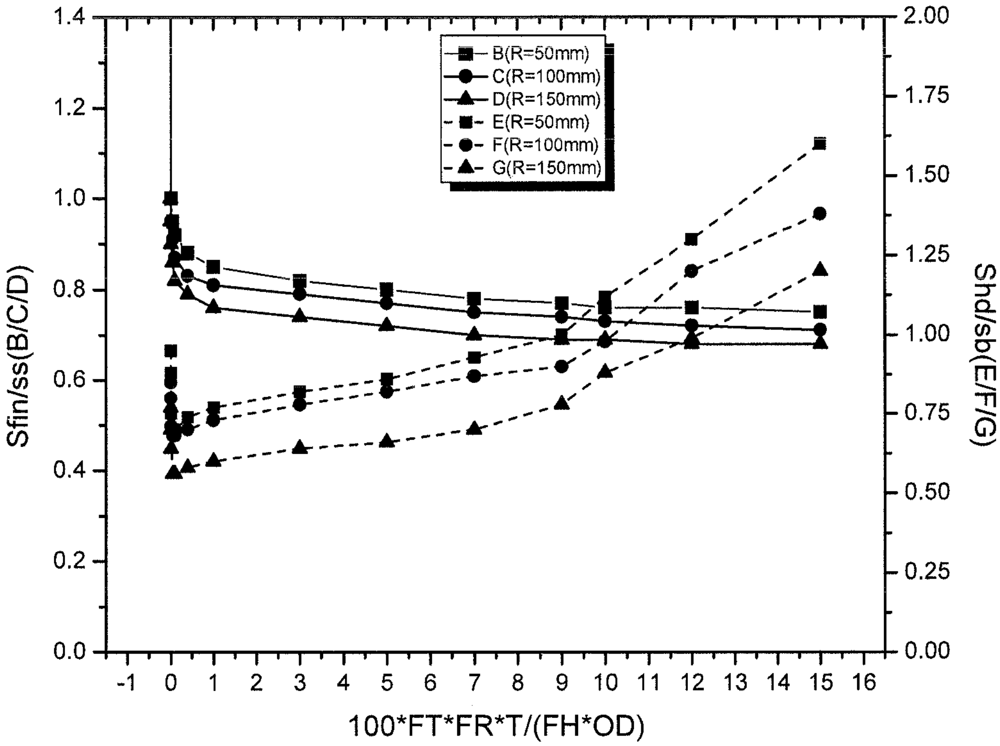
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Sfin/ss(B/C/D)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Shd/sb(E/F/G)
B(R=50mm)
C(R=100mm)
D(R=150mm)
E(R=50mm)
F(R=100mm)
G(R=150mm)
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
100*FT*FR*T/(FH*OD)

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/078406

A. CLASSIFICATION OF SUBJECT MATTER

F28D 1/053 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28D, F28F, F25B 39

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT, CNKI, VEN: bend, arc, header, manifold, angle, radius

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 103925745 A (SANHUA (HANGZHOU) MICRO CHANNEL HEAT EXCHANGER CO., LTD.), 16 July 2014 (16.07.2014), claims 1-11	1-11
A	CN 103411446 A (SANHUA (HANGZHOU) MICRO CHANNEL HEAT EXCHANGER CO., LTD.), 27 November 2013 (27.11.2013), description, paragraphs [0034]-[0040], and figures 1-2	1-11
A	CN 1191297 A (MODINE MANUFACTURING COMPANY), 26 August 1998 (26.08.1998), the whole document	1-11
A	CN 102390012 A (DANFOSS-SANHUA (HANGZHOU) MICRO CHANNEL HEAT EXCHANGER CO., LTD.), 28 March 2012 (28.03.2012), the whole document	1-11
A	JP 2002243381 A (DAIKIN IND LTD.), 28 August 2002 (28.08.2002), the whole document	1-11
A	JP 2000356294 A (SANOH IND CO., LTD.), 26 December 2000 (26.12.2000), the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 July 2015 (21.07.2015)	**11 August 2015 (11.08.2015)**

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Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/078406

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		EP 0855567 B1	06 November 2002
CN 102390012 A	28 March 2012	None	
JP 2002243381 A	28 August 2002	None	
JP 2000356294 A	26 December 2000	None	

Form PCT/ISA/210 (patent family annex) (July 2009)