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

(11) EP 2 684 003 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
16.12.2015 Bulletin 2015/51

(21) Application number: **11713248.0**

(22) Date of filing: **06.04.2011**

(51) Int Cl.:
F28F 1/40 *(2006.01)* ***F28F 13/18*** *(2006.01)*

(86) International application number:
PCT/EP2011/055295

(87) International publication number:
WO 2012/119661 (13.09.2012 Gazette 2012/37)

(54) **HEAT TRANSFER PIPE FOR HEAT EXCHANGER**

WÄRMEÜBERTRAGUNGSROHR FÜR WÄRMETAUSCHER

CONDUIT DE TRANSFERT DE CHALEUR POUR ÉCHANGEUR DE CHALEUR

(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

(30) Priority: **10.03.2011 CN 201110057011**

(43) Date of publication of application:
15.01.2014 Bulletin 2014/03

(73) Proprietor: **Luvata Espoo Oy**
021 01 Espoo (FI)

(72) Inventor: **DENG, Wenjia**
Zhongshan
Guangdong (CN)

(74) Representative: **Eurenius, Karin Lisa Maria et al**
Bjerkéns Patentbyrå KB
P.O. Box 1274
801 37 Gävle (SE)

(56) References cited:
WO-A1-2010/137647
JP-A- 10 197 184
JP-A- 61 175 485
US-A1- 2007 234 871

EP 2 684 003 B1

Description

TECHNICAL FIELD

[0001] This invention relates to a heat transfer pipe for heat exchanger, more particularly to a heat transfer pipe with helical rifling or helical primary teeth. JP-61 175 485 A discloses a heat pipe having the features in the preamble of claims 1 and 9. **BACKGROUND**

[0002] A heat exchanger is an apparatus that makes it possible to exchange energy between two or more fluids for the purpose of heating, cooling and etc. In a heat exchanger regularly used nowadays, fluids under heat exchange are separated from each other with a solid dividing wall or a third fluid. The design of the heat transfer pipe for the heat transfer has great influence on the operating efficiency of the heat exchanger.

[0003] Fig. 1 shows a typical heat transfer apparatus 100, which comprises a plurality of fins 101 and a plurality of heat exchange pipes 102. Lines of holes are provided in the fins 101 , and the heat exchange pipes are inserted into these holes. During operation, a first fluid enters into the heat transfer pipe system comprising the plurality of heat exchange pipes 102, as the arrow A1 indicates, then passes through the heat exchange pipes 102 while undergoing heat exchange and thereafter flows out in a direction as the arrow A2 indicates; a second fluid enters into a space among the fins 101 as the arrow B1 indicates, then undergoes heat exchange with the first fluid in the heat exchange pipes 102 and thereafter flows out in a direction as the arrow B2 indicates.

[0004] In an apparatuses for cooling, conditioning, freezing, or refrigerating, the first fluid (internal fluid) is usually a cold media, while the second fluid (external fluid) is air. The cold media undergoes phase change while flowing in the heat transfer pipes 102, the heat released or adsorbed thereof is transferred to the air via the heat transfer pipes 102 and the fins 101. The configuration of the inner surface of a heat transfer pipe 102 requires special designing to enhance the phase change heat transfer, so as to effectively assist the energy exchange between the internal and external fluids.

[0005] A conventional heat transfer pipe usually uses a seamless copper pipe, whose inner surface is provided with helical teeth to increase the area of the inner surface, to keep the inner surface wet or covered with a thin liquid film, to enhance the liquid turbulence, to destruct the flowing boundary layer, and to provide the effect of heat exchange. On the basis of this, some heat transfer pipes are provided with, in addition to the primary teeth, intermittent secondary teeth with lower heights and disposed between the primary teeth, which results in further increasing the roughness within the heat transfer pipes. In this way, it is possible to provide more cores for condensing or vaporizing, to enhance the liquid turbulence, and thereby to further improve the effect of convection heat transfer.

[0006] Notwithstanding the above, on the other hand, absent well-founded arrangement of the secondary teeth, the flow resistance to the fluid in an heat transfer pipe will be increased, the system must increase the power to assure that the fluid passes through the heat exchanger at the design rate, while the extra power means a lower operating efficiency of the whole system. Moreover, the shaping and positioning of the secondary teeth is not optimized with regard to the kinetics of the fluid, it is thereupon inconvenient to manufacture, which, *de facto,* raises the cost of manufacturing.

SUMMARY OF THE INVENTION

[0007] The invention, intending to solve the aforementioned problems, provides a heat transfer pipe for heat exchanger, which can improve the heat transfer efficiency while not significantly increasing the transfer resistance to a fluid, and has a simple structure as well as low manufacturing cost.

[0008] According to a first aspect according to the invention, a heat transfer pipe for heat exchanger is provided, an inner surface of the heat transfer pipe being provided alternately with a plurality of helical primary teeth and a plurality of grooves, each groove being disposed between adjacent primary teeth, wherein a protrusion set is provided in at least one groove, the protrusion set comprises a plurality of protrusions sequentially and intermittently disposed in an extending direction of the primary teeth, and each protrusion has a radial height lower than the radial heights of the primary teeth, and wherein at least one groove having no protrusion set is provided between the adjacent ones of the grooves each having a protrusion set. Preferably, 4 or 5 grooves each having no protrusion set are disposed between adjacent ones of grooves each having a protrusion set.

[0009] According to a second aspect according to the invention, a heat transfer pipe for heat exchanger is provided, an inner surface of the heat transfer pipe being provided alternately with a plurality of helical primary teeth and a plurality of grooves, each groove being disposed between adjacent primary teeth, wherein protrusion sets are provided in the grooves on both sides of at least one primary tooth in a circumferential direction of the heat transfer pipe, each protrusion set comprises a plurality of protrusions sequentially and intermittently disposed in an extending direction of the at least one primary tooth, and each protrusion has a radial height lower than that of the at least one primary tooth, and wherein at least one primary tooth with no protrusion set disposed on either side is disposed between adjacent ones of the primary teeth with protrusion sets disposed on both sides. Preferably, 4 or 5 primary teeth each having no protrusion set disposed on either side are disposed between adjacent ones of primary teeth each having protrusion sets on both sides.

[0010] With the above heat transfer pipe, on the one hand, the presence of the protrusions enhances the fluid (such as cooling agent or cold media) turbulence evoked by the bottoms of the primary teeth, and assists in forming more cores for bubbles during evaporation, and thus improves the efficiency of heat exchange; on the other hand, not all, but every few, grooves between the primary teeth are provided with protrusions, which suppresses significantly increasing flow resistance of a fluid, avoids too great a pressure decrease, and at the same time results in low manufacturing cost.

[0011] Preferably, the width of each protrusion in the circumferential direction of the heat transfer pipe is smaller than the width of the groove where the each protrusion is located in the circumferential direction of the heat transfer pipe. This further reduces the resistance of protrusions to a fluid. Moreover, a protrusion is only provided on part of the wide of a groove in the circumferential direction, which further destructs the formation of the boundary layer of a fluid, enhances the turbulence, and thus improves the effect of heat exchange.

[0012] Preferably, the side of each protrusion in the circumferential direction of the heat transfer pipe is formed on a side surface of one of the two primary teeth adjacent to the groove where the each protrusion is located. Here, the sides of protrusions of a same protrusion set can be formed on a side surface of a same primary tooth, and can also be formed on side surfaces of different primary teeth.

[0013] The protrusion according to the above embodiments can be molded with a continuous casting process.

[0014] Preferably, section of each protrusion that is perpendicular to the circumferential direction of the heat transfer pipe is a trapezoidal. The ratios of the radial height of each protrusion to the radial heights of the primary teeth can be between 0.05-0.5. The protrusions configured according to such preferred embodiments are more advantageous for formation of cores for condensing or vaporization and enhances the turbulence.

[0015] Preferably, the protrusions in a same protrusion set are disposed at equal intervals. Such an arrangement is more amiable for manufacturing.

[0016] According to one embodiment, the radial height of each protrusion is gradually decreased from the side of the protrusion that is formed on a side surface of a primary tooth and in the extending direction of the primary tooth. The protrusion thus formed leads to less resistance to a fluid and avoidance of too great a pressure decrease, which improves the operating efficiency of the whole heat exchanger. Particularly, the protrusions can be formed into such shapes as sickles, crescents, horns, or the similar.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is the schematic perspective view of a conventional heat exchanger;

Fig. 2 is a schematic perspective view of a part of the heat transfer pipe according to the first embodiment of the invention;

Fig. 3 is a sectional perspective view of a part of the heat transfer pipe according to the first embodiment of the invention;

Fig. 3A is the enlarged view of one protrusion in the heat transfer pipe; and

Fig. 4 is a sectional perspective view of a part of the heat transfer pipe according to the second embodiment of the invention.

DETAILED DESCRIPTION

[0018] Hereinafter, particular embodiments of the heat transfer pipe for heat exchanger according to the invention are described in detail with references to the drawings.

[0019] Fig. 2 shows a schematic perspective view of a part of a heat transfer pipe 1 according to the first embodiment of the invention. As shown in Fig. 2, the heat transfer pipe 1 is formed as a cylinder pipe, preferably of copper. Without doubt, the heat transfer pipe 1 can be made of other alloy materials. A plurality of helical primary teeth 2 are manufactured and formed in the inner surface of the heat transfer pipe 1 (particularly, shown as 21, ..., 26, and 27 in Fig. 3). Accordingly, grooves 3 are formed between two adjacent primary teeth (particularly, shown as 31, 32, 33, 34, 35, and 36 in Fig. 3). Furthermore, protrusions 41 disposed intermittently and having heights lower than primary teeth are formed in some of the grooves 3. The protrusions further increase the roughness within the heat transfer pipe, provide more cores for condensing or vaporizing, build and maintain a thin liquid layer of the inner surface, increase the fluid turbulence in the proximate of the surface, and therefore increase the convection heat transfer coefficient.

[0020] More particularly, Fig. 3 shows a sectional perspective view of a part of the aforementioned heat transfer pipe 1. As shown in Fig. 3, a protrusion set comprising a line of protrusions 41 is formed in the groove 31, and another protrusion set is formed in the groove 36. Between the grooves 31 and 36 are provided 4 grooves 32, 33, 34, and 35 having no protrusion set. With the protrusions 41 distributed in this way, it is possible to provide more cores for condensing or vaporizing, to avoid too great a pressure decrease, and at the same time to reduce manufacturing cost.

[0021] It should be known that the invention, not limited to the above, can have 2, 3, or more than 4 grooves having no protrusion set disposed between the grooves 31 and 36 each having a protrusion set. Although the figure only shows the case where a protrusion set comprises 2 or 3 protrusions 41, the number of the protrusions 41 in a protrusion set can be arbitrarily set in accordance with the length of the heat transfer pipe and the spacing between the protrusions 41. Furthermore, notwithstanding that the protrusions 41 in one protrusion set as shown in Fig. 3 are disposed at equal intervals (the interval in an axial direction between adjacent protrusions 41 is set to L), the invention, not limited to this, can have the protrusions 41 in one protrusion set disposed at varying intervals.

[0022] As shown in Fig. 3, in the circumferential direction of the heat transfer pipe 2, the widths of the protrusions 41 are smaller than the widths of the respective grooves. In this way, in comparison with the case where the widths of the protrusions 41 equal those of the respective grooves, the area a fluid passes through becomes larger, and the protrusions 41 impose a smaller resistance to the fluid. Furthermore, such a configuration can further destruct the formation of the boundary layer of a fluid, enhance the turbulence, and thus improve the effect of heat exchange.

[0023] As shown in Fig. 3, a side 411 (shown in Fig. 3A) of the protrusion 41 in the circumferential direction is formed on one side surface of the adjacent primary tooth 21 (in Fig. 3, the side surface on the right). Such a configuration is amiable for manufacturing. In the embodiment shown in Fig. 3, one side of each protrusion 41 in a same protrusion set is formed on a side surface of the same primary tooth. As an example, one side of each protrusion 41 of the protrusion set in the groove 31 is formed on a side surface 211 of the primary tooth 21, while one side of each protrusion 41 of the protrusion set in the groove 36 is formed on a corresponding side surface of the primary tooth 26.

[0024] Nevertheless, the invention, not limited to the above, can be provided in such a way where the adjacent protrusions 41 in a same protrusion set are formed on side surfaces of different primary teeth. As an example, as to the protrusion set in the groove 36, a first protrusion 41 can be formed on a side surface of the primary tooth 26, while a second protrusion 41 can formed on a side surface of the primary tooth 27, and so on in alternation. With such a disposition of the protrusions 41, it is possible to further destruct the formation of the boundary layer of a fluid and improve the effect of heat exchange.

[0025] Hereinafter, a description regarding the shape and size of a protrusion is given with references to Fig. 3A, which enlarges the view of the protrusion. The section of the protrusion 41 that is perpendicular to the circumferential direction is substantially a trapezoidal, whose side surfaces 411 is so formed as to be suitable for abutting the side surface of a primary tooth. If the radial height of the primary tooth is h, the size of the protrusion 41 can be set as follows:

$h_1 = 0.05\sim0.5h$;

$a = 0.05\sim0.5h$;

$b = 1\sim2h$;

$c = 0.05\sim0.85w$;

$d = 1.5\sim2.5h_o$

[0026] Furthermore, h can be set in the range of 0.07~0.23mm, L in the range of 0.5~15mm. As is apparent, the size as above is merely an example, it can adopt other suitable sizes according to practical application.

[0027] A description of a heat transfer pipe 1' according to the second embodiment is given below with references to Fig. 4. The heat transfer pipe 1' differs from the heat transfer pipe 1 according to the first embodiment mainly in the shaping and distribution of protrusions 41'.

[0028] As shown in Fig. 4, protrusions 41' are formed on both sides of a primary tooth 21'. Between grooves 21' and 26' that have protrusions, there are disposed a plurality of primary teeth 22', 23', 24' and 25' (the number of interposed primary teeth can vary). With such a distribution, it is possible to obtain effect similar to that of the embodiment as shown in Fig. 3. Similarly, the distribution of protrusions 41' can vary, as described above, on the basis of the embodiment shown in Fig. 4.

[0029] The radial height of a protrusion 41' is gradually decreased from the side of a side surface 211' that is formed on the primary tooth 21' and in the extending direction of the primary tooth (i.e., the axial direction), which forms the shape of a sickle as shown in Fig. 4. The protrusion thus formed leads to less resistance to a fluid and avoidance of too great a pressure decrease, which improves the operating efficiency of the whole heat exchanger and makes it amiable for manufacturing. Furthermore, the protrusions 41' can be formed into the shapes of crescents, horns, or the similar.

[0030] The features in the first embodiment and the second embodiment can be combined and varied in any suitable way. As an example, the first embodiment can be adapted for the protrusions 41' with the shapes shown in the second embodiment, while the second embodiment can be adapted for the protrusions 41 with the shapes shown in the first embodiment. For another example, the protrusions 41' on the two sides of the same primary tooth 21' in the second embodiment can have different shapes or orientations.

Claims

1. A heat transfer pipe (1) for heat exchanger, an inner surface of the heat transfer pipe being provided alternately with a plurality of helical primary teeth (2; 21, 22, 23, 24, 25, 26, 27) and a plurality of grooves (3; 31, 32, 33, 34, 35, 36), each groove being disposed between adjacent primary teeth,
wherein a protrusion set is provided in at least one groove (31, 36), the protrusion set comprises a plurality of protrusions (41) sequentially and intermittently disposed in an extending direction of the primary teeth, and each protrusion (41) has a radial height lower than those of the primary teeth,
and **characterised in that** at least one groove having no protrusion set (32, 33, 34, 35) is provided between the adjacent ones (31, 36) of the grooves each

having a protrusion set.

2. The heat transfer pipe (1) according to claim 1, wherein the width of each protrusion (41) in a circumferential direction of the heat transfer pipe (1) is smaller than the width of the groove (31, 36) where the each protrusion is located in the circumferential direction of the heat transfer pipe (1).

3. The heat transfer pipe (1) according to claim 2, wherein the side (411) of each protrusion (41) in the circumferential direction of the heat transfer pipe (1) is formed on a side surface (211) of one of the two primary teeth (21, 22, 26, 27) adjacent to the groove (31, 36) where the each protrusion is located.

4. The heat transfer pipe (1) according to claim 3, wherein the side of each protrusion (41) of a same protrusion set in the circumferential direction of the heat transfer pipe (1) is formed on a side surface (211) of the same primary tooth (21,26).

5. The heat transfer pipe (1) according to claim 3, wherein the sides of adjacent protrusions (41) in a same protrusion set in the circumferential direction of the heat transfer pipe (1) are formed on side surfaces of different primary teeth.

6. The heat transfer pipe (1) according to any one of claims 1-5, wherein 4 or 5 grooves each having no protrusion set are disposed between adjacent ones of grooves each having a protrusion set.

7. The heat transfer pipe (1) according to any one of claims 1-5, wherein the section of each protrusion (41) that is perpendicular to the circumferential direction of the heat transfer pipe (1) is a trapezoidal, preferably wherein the ratios of the radial height of each protrusion (41) to the radial heights of the primary teeth are between 0.05-0.5.

8. The heat transfer pipe (1) according to any one of claims 3-5, wherein the radial height of each protrusion (41) is gradually decreased from the side of the protrusion (41) that is formed on said side surface of the primary tooth and in the extending direction of the primary tooth.

9. A heat transfer pipe (1') for heat exchanger, an inner surface of the heat transfer pipe being provided alternately with a plurality of helical primary teeth (21', 22', 23', 24', 25',26',27') and a plurality of grooves, each groove being disposed between adjacent primary teeth,
wherein protrusion sets are provided in the grooves on both sides of at least one primary tooth (21', 26') in a circumferential direction of the heat transfer pipe (1'), each protrusion set comprises a plurality of protrusions (41') sequentially and intermittently disposed in an extending direction of the at least one primary tooth (21', 26'), and each protrusion (41') has a radial height lower than that of the at least one primary tooth (21', 26'),
and **characterised in that** at least one primary tooth (22', 23', 24', 25') having no protrusion set disposed on either side is disposed between adjacent ones of the primary teeth (21', 26') with protrusion sets disposed on both sides.

10. The heat transfer pipe according to claim 9, wherein the width of each protrusion (41') in the circumferential direction of the heat transfer pipe (1') is smaller than the width of the groove where the each protrusion is located in the circumferential direction of the heat transfer pipe (1').

11. The heat transfer pipe according to claim 10, wherein for each primary tooth (21', 26') having protrusion sets disposed on both sides, the side of each protrusion (41') of the protrusion sets in the circumferential direction of the heat transfer pipe is formed on one side of the each primary tooth (21', 26').

12. The heat transfer pipe according to any one of claims 9-11, wherein 4 or 5 primary teeth each having no protrusion set disposed on either side are disposed between adjacent ones of primary teeth each having protrusion sets on both sides.

13. The heat transfer pipe according to any one of claims 9-11, wherein the section of each protrusion (41') that is perpendicular to the circumferential direction of the heat transfer pipe is a trapezoidal, preferably wherein the ratios of the radial height of each protrusion (41') to those of the primary teeth are between 0.05-0.5.

14. The heat transfer pipe according to any one of claims 1-5 or 9-11, wherein the protrusions (41, 41') in a same protrusion set are disposed at equal intervals.

15. The heat transfer pipe according to claim 11, wherein the radial height of said each protrusion (41') of the protrusion sets is gradually decreased from the side of the protrusion (41') that is formed on said side surface (211') of the primary tooth (21') and in the extending direction of the primary tooth.

Patentansprüche

1. Wärmeübertragungsrohr (1) für einen Wärmetauscher, bei dem eine Innenfläche des Wärmeübertragungsrohres abwechselnd mit einer Vielzahl von schraubenförmigen primären Zähnen (2; 21, 22, 23, 24, 25, 26, 27) und einer Vielzahl von Nuten (3; 31,

32, 33, 34, 35, 36) versehen ist und jede Nut zwischen benachbarten primären Zähnen angeordnet ist,
wobei ein Satz von Vorsprüngen in mindestens einer Nut (31, 36) vorgesehen ist, der Satz von Vorsprüngen eine Mehrzahl von Vorsprüngen (41) umfasst, die nacheinander und in Abständen in einer Erstreckungsrichtung der primären Zähne angeordnet sind, und die radiale Höhe jedes Vorsprungs (41) niedriger ist als die radialen Höhen der primären Zähne,
dadurch gekennzeichnet, dass zumindest eine Nut, die keinen Satz von Vorsprüngen (32, 33, 34, 35) aufweist, zwischen den benachbarten Nuten (31, 36) derjenigen Nuten, welche jeweils einen Satz von Vorsprüngen aufweisen, vorgesehen ist.

2. Wärmeübertragungsrohr (1) nach Anspruch 1, bei dem die Breite jedes Vorsprungs (41) in einer Umfangsrichtung des Wärmeübertragungsrohres (1) kleiner ist als die Breite der Nut (31, 36) in der Umfangsrichtung des Wärmeübertragungsrohrs (1), in welcher der Vorsprung angeordnet ist.

3. Wärmeübertragungsrohr (1) nach Anspruch 2, bei dem die Seite (411) jedes Vorsprungs (41) in der Umfangsrichtung des Wärmeübertragungsrohres (1) an einer Seitenfläche (211) eines der beiden primären Zähne (21, 22, 26, 27) ausgebildet ist, die an die Nut (31, 36), in welcher der Vorsprung angeordnet ist, angrenzen.

4. Wärmeübertragungsrohr (1) nach Anspruch 3, bei dem die Seite jedes Vorsprungs (41) ein und desselben Satzes von Vorsprüngen in der Umfangsrichtung des Wärmeübertragungsrohres (1) an einer Seitenfläche (211) desselben primären Zahns (21, 26) ausgebildet ist.

5. Wärmeübertragungsrohr (1) nach Anspruch 3, bei dem die Seiten benachbarter Vorsprünge (41) in ein und demselben Satz von Vorsprüngen in der Umfangsrichtung des Wärmeübertragungsrohrs (1) an Seitenflächen verschiedener primärer Zähne ausgebildet sind.

6. Wärmeübertragungsrohr (1) nach einem der Ansprüche 1-5, bei dem 4 oder 5 Nuten, die jeweils keine Vorsprünge aufweisen, zwischen benachbarten Nuten derjenigen Nuten, die jeweils einen Satz Vorsprünge aufweisen, angeordnet sind.

7. Wärmeübertragungsrohr (1) nach einem der Ansprüche 1-5, bei dem der Querschnitt jedes Vorsprungs (41), der senkrecht zur Umfangsrichtung des Wärmeübertragungsrohres (1) steht, trapezförmig ist, wobei vorzugsweise die Verhältnisse der radialen Höhe jedes Vorsprungs (41) zu den radialen Höhen der primären Zähne zwischen 0,05-0,5 betragen.

8. Wärmeübertragungsrohr (1) nach einem der Ansprüche 3-5, bei dem sich die radiale Höhe jedes Vorsprungs (41) allmählich von der Seite des Vorsprungs (41) aus, die an der besagten Seitenfläche des primären Zahns ausgebildet ist, und in der Erstreckungsrichtung des primären Zahns verringert.

9. Wärmeübertragungsrohr (1’) für einen Wärmetauscher, bei dem eine Innenfläche des Wärmeübertragungsrohres abwechselnd mit einer Vielzahl von schraubenförmigen primären Zähnen (21’, 22’, 23’, 24’, 25’, 26’, 27’) und einer Vielzahl von Nuten versehen ist und jede Nut zwischen benachbarten primären Zähnen angeordnet ist,
wobei in den Nuten Sätze von Vorsprüngen auf beiden Seiten mindestens eines primären Zahnes (21’, 26’) in einer Umfangsrichtung des Wärmeübertragungsrohres (1’) vorgesehen sind, jeder Satz Vorsprünge eine Mehrzahl von Vorsprüngen (41’) umfasst, die nacheinander und in Abständen in einer Erstreckungsrichtung des wenigstens einen primären Zahns (21’, 26’) angeordnet sind, und jeder Vorsprung (41’) eine radiale Höhe aufweist, die niedriger ist als die des mindestens einen primären Zahns (21’, 26’),
dadurch gekennzeichnet, dass mindestens ein primärer Zahn (22’, 23’, 24’, 25’), der auf keiner Seite einen Satz von Vorsprüngen aufweist, zwischen benachbarten Zähnen derjenigen primären Zähne (21’, 26’), die Sätze von Vorsprüngen auf beiden Seiten aufweisen, angeordnet ist.

10. Wärmeübertragungsrohr nach Anspruch 9, bei dem die Breite jedes Vorsprungs (41’) in der Umfangsrichtung des Wärmeübertragungsrohres (1’) kleiner ist als die Breite der Nut in der Umfangsrichtung des Wärmeübertragungsrohres (1’), in welcher der Vorsprung angeordnet ist.

11. Wärmeübertragungsrohr nach Anspruch 10, bei dem bei jedem primären Zahn (21’, 26’), der Sätze von Vorsprüngen an beiden Seiten aufweist, die Seite eines jeden Vorsprungs (41’) der Sätze von Vorsprüngen in der Umfangsrichtung des Wärmeübertragungsrohres an einer Seite des primären Zahns (21’, 26’) ausgebildet ist.

12. Wärmeübertragungsrohr nach einem der Ansprüche 9-11, bei dem 4 oder 5 primäre Zähne, die jeweils keine Vorsprünge auf beiden Seiten aufweisen, zwischen benachbarten Zähnen derjenigen primären Zähne, die jeweils Sätze von Vorsprüngen auf beiden Seiten aufweisen, angeordnet sind.

13. Wärmeübertragungsrohr nach einem der Ansprüche 9-11, bei dem der Querschnitt jedes Vorsprungs (41'), der senkrecht zur Umfangsrichtung des Wärmeübertragungsrohres steht, trapezförmig ist, wobei vorzugsweise die Verhältnisse der radialen Höhe jedes Vorsprungs (41') zu den radialen Höhen der primären Zähne zwischen 0,05-0,5 betragen.

14. Wärmeübertragungsrohr nach einem der Ansprüche 1-5 oder 9-11, bei dem die Vorsprünge (41, 41') in ein und demselben Satz von Vorsprüngen in gleichen Abständen angeordnet sind.

15. Wärmeübertragungsrohr nach Anspruch 11, bei dem sich die radiale Höhe jedes Vorsprungs (41') der Sätze von Vorsprüngen allmählich von der Seite des Vorsprungs (41') aus, die an der besagten Seitenfläche (211') des primären Zahns (21') ausgebildet ist, und in der Erstreckungsrichtung des primären Zahns verringert.

Revendications

1. Conduit de transfert de chaleur (1) pour un échangeur de chaleur, une surface interne du conduit de transfert de chaleur étant pourvue de manière alternée d'une pluralité de dents primaires hélicoïdales (2, 21, 22, 23, 24, 25, 26, 27) et une pluralité de gorges (3, 31, 32, 33, 34, 35, 36), chaque gorge étant placée entre des dents primaires adjacentes,
dans lequel un jeu de protubérances est prévu dans au moins une gorge (31, 36), le jeu de protubérances est composé d'une pluralité de protubérances (41) placées de manière séquentielle et intermittente dans une direction d'extension des dents primaires et chaque protubérance (41) a une hauteur radiale inférieure à celle des dents primaires,
et **caractérisé en ce qu'**au moins une gorge n'ayant pas de jeu de protubérances (32, 33, 34, 35) est prévue entre les gorges adjacentes (31, 36) ayant chacune un jeu de protubérances.

2. Conduit de transfert de chaleur (1) selon la revendication 1, **caractérisé en ce que** la largeur de chaque protubérance (41) dans la direction de la circonférence du conduit de transfert de chaleur (1) est inférieure à la largeur de la gorge (31, 36) où chacune des protubérances est située dans la direction de la circonférence du conduit de transfert de chaleur (1).

3. Conduit de transfert de chaleur (1) selon la revendication 2, **caractérisé en ce que** la paroi (411) de chaque protubérance (41) dans la direction de la circonférence du conduit de transfert de chaleur (1) est formée sur une surface latérale (211) d'une des deux dents primaires (21, 22, 26, 27) adjacente à la gorge (31, 36) où chaque protubérance est située.

4. Conduit de transfert de chaleur (1) selon la revendication 3, **caractérisé en ce que** la paroi de chaque protubérance (41) d'un même jeu de protubérance dans la direction de la circonférence du conduit de transfert de chaleur (1) est formé sur une surface latérale (211) de la même dent primaire (21, 26).

5. Conduit de transfert de chaleur (1) selon la revendication 3, **caractérisé en ce que** les parois des protubérances adjacentes (41) dans un même jeu de protubérances dans la direction de la circonférence du conduit de transfert de chaleur (1) sont formées sur des surfaces latérales de différentes dents primaires.

6. Conduit de transfert de chaleur (1) selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** 4 ou 5 gorges n'ayant chacune aucun jeu de protubérances sont placées entre des gorges adjacents ayant chacune un jeu de protubérances.

7. Conduit de transfert de chaleur (1) selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** la section de chaque protubérance (41) qui est perpendiculaire à la direction de la circonférence du conduit de transfert de chaleur (1) est un trapézoïde, de préférence dans lequel les rapports entre la hauteur radiale de chaque protubérance (41) et les hauteurs radiales des dents primaires sont compris entre 0,05 et 0,5.

8. Conduit de transfert de chaleur (1) selon l'une quelconque des revendications 3 à 5, **caractérisé en ce que** la hauteur radiale de chaque protubérance (41) diminue graduellement à partir de la paroi de la protubérance (41) qui est formée sur la dite surface latérale de la dent primaire et dans la direction d'extension de la dent primaire.

9. Conduit de transfert de chaleur (1') pour un échangeur de chaleur, une surface interne du conduit de transfert de chaleur étant pourvue, de manière alternée, d'une pluralité de dents primaires hélicoïdales (21', 22', 23', 24', 25', 26', 27') et une pluralité de gorges, chaque gorge étant placée entre des dents primaires adjacentes,
dans lequel des jeux de protubérances sont prévus dans les gorges de chaque côté d'au moins une dent primaire (21', 26') dans la direction de la circonférence du conduit de transfert de chaleur (1'), chaque jeu de protubérances est composé d'une pluralité de protubérances (41') placées de manière séquentielle et intermittente dans une direction d'extension de la au moins une dent primaire (21', 26'), et chaque protubérance (41') présente une hauteur radiale inférieure à celle de la au moins une dent primaire (21', 26'),
et **caractérisé en ce qu'**au moins une dent primaire

(22', 23', 24', 25') n'ayant pas de jeu de protubérances placé sur ses parois est placée entre des dents primaires adjacentes (21', 26') ayant des jeux de protubérances placés sur ses deux parois.

10. Conduit de transfert de chaleur selon la revendication 9, **caractérisé en ce que** la largeur de chaque protubérance (41') dans la direction de la circonférence du conduit de transfert de chaleur (1') est inférieure à la largeur de la gorge où chacune des protubérances est située dans la direction de la circonférence du conduit de transfert de chaleur (1').

11. Conduit de transfert de chaleur selon la revendication 10, **caractérisé en ce que** pour chaque dent primaire (21', 26') ayant des jeux de protubérances placés sur les deux parois, la paroi de chaque protubérance (41') des jeux de protubérances dans la direction de la circonférence du conduit de transfert de chaleur est formée sur une paroi de chacune des dents primaires (21', 26').

12. Conduit de transfert de chaleur selon l'une quelconque des revendications 9 à 11, **caractérisé en ce que** 4 ou 5 dents primaires chacune n'ayant aucun jeu de protubérance placé sur aucune paroi sont placées entre des dents primaires adjacentes ayant chacune des jeux de protubérances sur leurs deux parois.

13. Conduit de transfert de chaleur selon l'une quelconque des revendications 9 à 11, **caractérisé en ce que** la section de chaque protubérance (41') qui est perpendiculaire à la direction de la circonférence du conduit de transfert de chaleur est un trapézoïde, de préférence dans lequel les rapports entre la hauteur radiale de chaque protubérance (41') et celles des dents primaires sont compris entre 0,05 et 0,5.

14. Conduit de transfert de chaleur selon l'une quelconque des revendications 1 à 5 ou 9 à 11, **caractérisé en ce que** les protubérances (41, 41') dans un même jeu de protubérances sont placées à des intervalles égaux.

15. Conduit de transfert de chaleur selon la revendication 11, **caractérisé en ce que** la hauteur radiale de chacune des dites protubérances (41') des jeux de protubérance diminue graduellement à partir de la paroi de la protubérance (41') qui est formée sur la dite surface latérale (211') de la dent primaire (21') et dans la direction d'extension de la dent primaire.

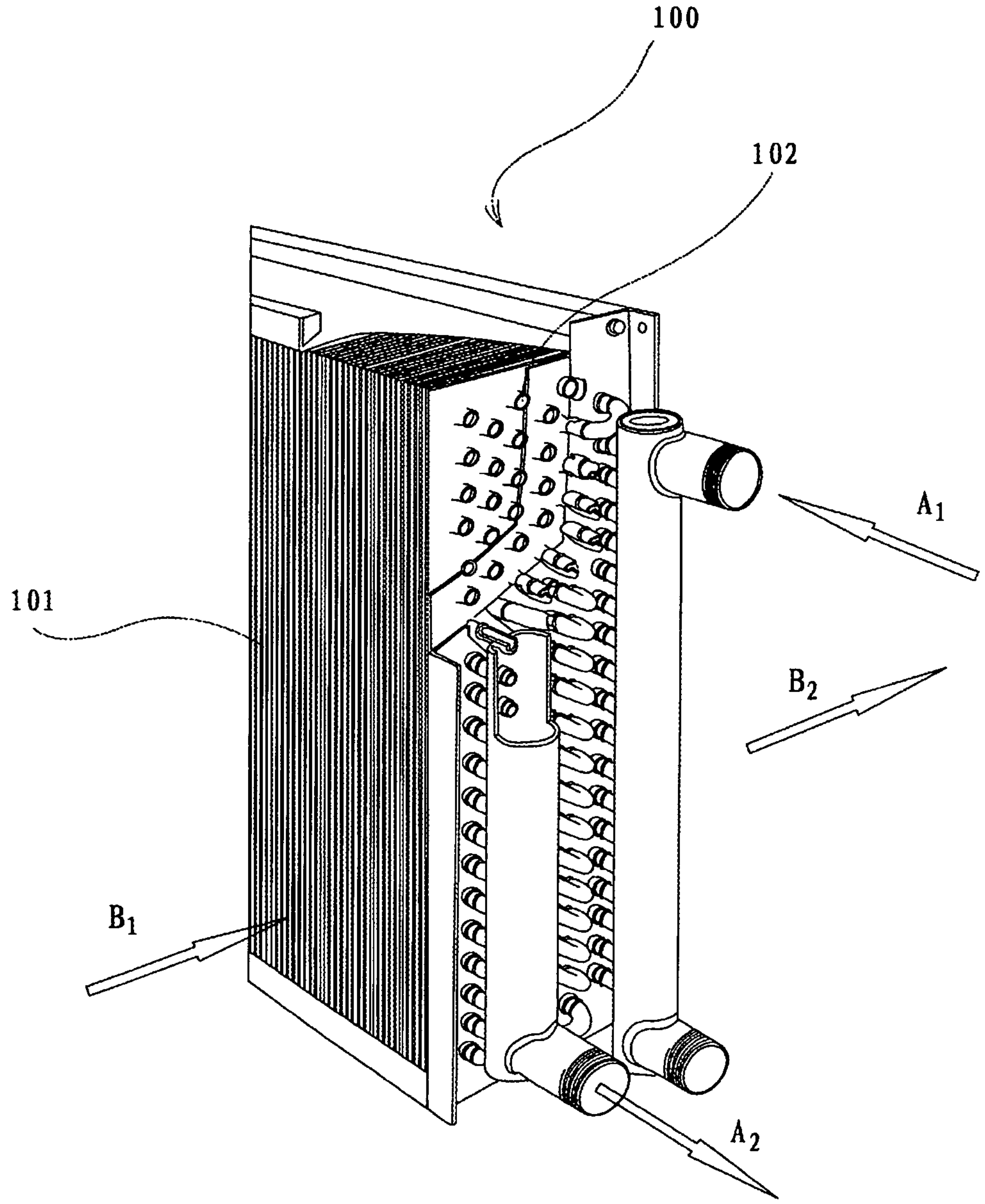

Fig.1

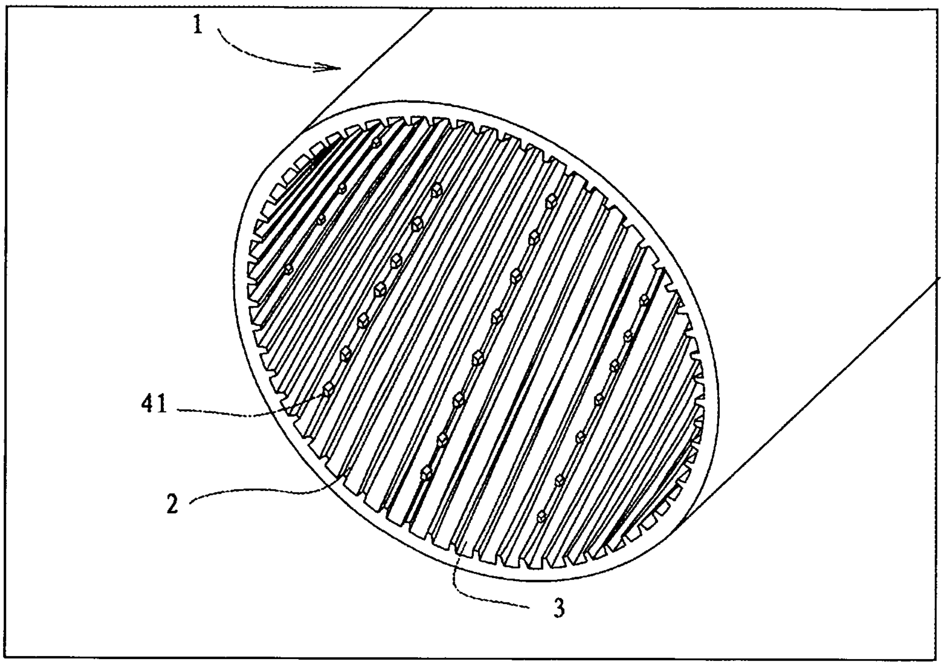

Fig.2

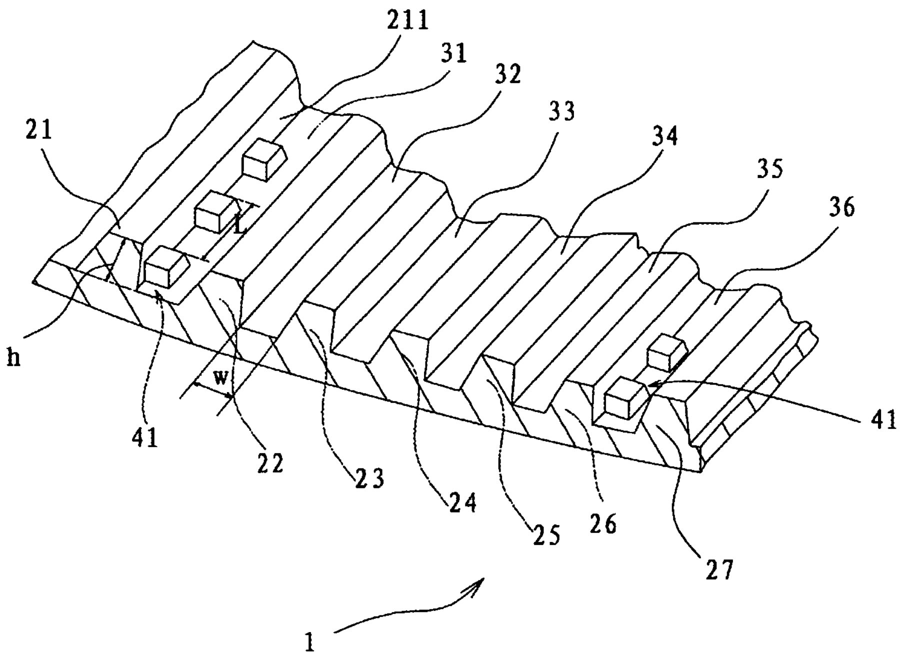

Fig.3

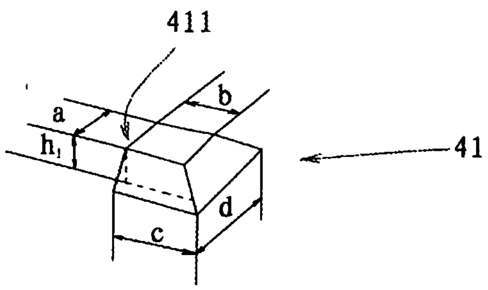

Fig.3A

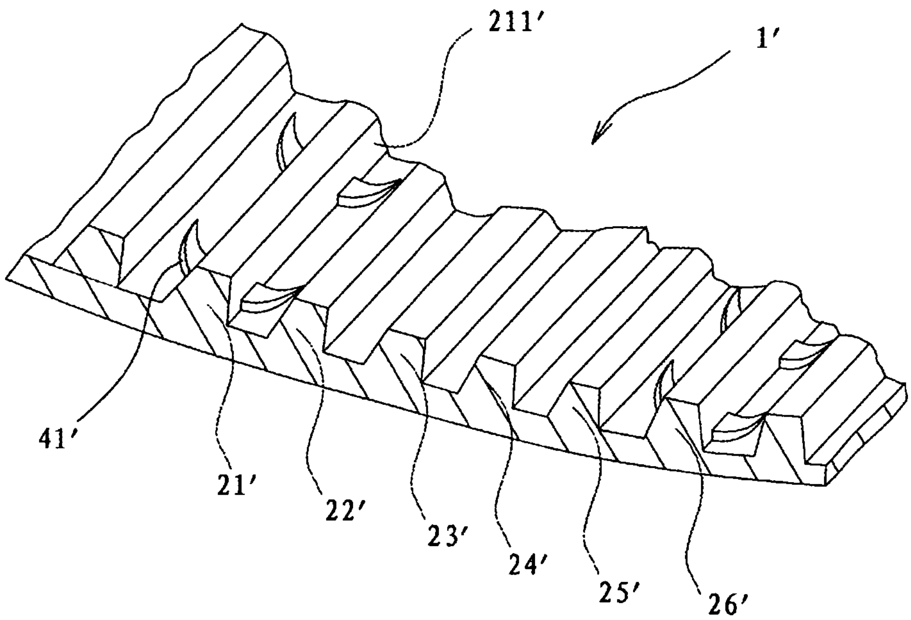

Fig.4

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 61175485 A **[0001]**