A heat exchanger according to the present invention, in which a cylindrical channel is formed by the inner-circumferential surface of the outside heat-exchanger tube and the outer-circumferential surface of the inside heat-exchanger tube, and heat is exchanged between a first heat transfer medium flowing through the channel and a second heat transfer medium on the outside of the outside heat-exchanger tube or on the inside of the inside heat-exchanger tube, wherein: the cylindrical channel is provided with an intermediate heat-exchanger tube in which convex and concave sections are formed in an alternating manner in the circumferential direction of the channel; at least some of the peaks of the convex sections or at least some of the troughs of the concave sections of the intermediate heat-exchanger tube contact the heat-exchanger tube that contacts the second heat transfer medium among the outside and inside heat-exchanger tubes; and a plurality of openings extending from the outer-circumferential surface of the intermediate heat-exchanger tube to the inner-circumferential surface thereof are formed in a region between the peaks and troughs of the intermediate heat-exchanger tube.
DESCRIPTION
Title of Invention

HEAT EXCHANGER AND REFRIGERATION CYCLE APPARATUS USING THE SAME

Technical Field

[0001]

The present invention relates to a heat exchanger and a refrigeration cycle apparatus using the same.

Background Art

[0002]

There is an existing heat exchanger in which an inner circumferential surface of an outer heat transfer pipe and an outer circumferential surface of an inner heat transfer pipe form a tubular flow path, and a first heat medium flowing through the flow path and a second heat medium outside the outer heat transfer pipe or inside the inner heat transfer pipe exchange heat. The tubular flow path is provided with an intermediate heat transfer pipe having projections and recesses alternately formed in the circumferential direction of the flow path such that at least a part of tops of the projections or at least a part of bottoms of the recesses is in contact with one of the outer heat transfer pipe and the inner heat transfer pipe being in contact with the second heat medium, thereby expanding a heat transfer area (see Patent Literature 1, for example).

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2012-63067 (paragraph [0057] to paragraph [0061], Fig. 6, and Fig. 7)

Summary of Invention
Technical Problem

[0004]

Such a heat exchanger has a problem that, after the first heat medium flows in from the upstream side of the intermediate heat transfer pipe and divides into a flow path between the inner circumferential surface of the outer heat transfer pipe and an outer circumferential surface of the intermediate heat transfer pipe (hereinafter referred to as the intermediate heat transfer pipe outer flow path) and a flow path between the outer circumferential surface of the inner heat transfer pipe and an inner circumferential surface of the intermediate heat transfer pipe (hereinafter referred to as the intermediate heat transfer pipe inner flow path), the first heat medium is unable to move back and forth between the intermediate heat transfer pipe outer flow path and the intermediate heat transfer pipe inner flow path, thereby making the flow rate of the first heat medium flowing through the respective flow paths not uniform and reducing the heat exchange efficiency. There is also a problem that the heat exchange efficiency is reduced owing to insufficient stirring.

[0005]

The present invention has been made in view of the above-described problems as background, and aims to obtain a heat exchanger having improved heat exchange efficiency. The present invention further aims to obtain a refrigeration cycle apparatus using the heat exchanger having improved heat exchange efficiency.

Solution to Problem

[0006]

In a heat exchanger according to the present invention, an inner circumferential surface of an outer heat transfer pipe and an outer circumferential surface of an inner heat transfer pipe form a tubular flow path, and a first heat
medium flowing through the flow path and a second heat medium outside the outer heat transfer pipe or inside the inner heat transfer pipe exchange heat. The tubular flow path is provided with an intermediate heat transfer pipe having projections and recesses alternately formed in a circumferential direction of the flow path. At least a part of tops of the projections or at least a part of bottoms of the recesses of the intermediate heat transfer pipe is in contact with one of the outer heat transfer pipe and the inner heat transfer pipe being in contact with the second heat medium. Areas of the intermediate heat transfer pipe between the tops and the bottoms are formed with a plurality of first openings passing through from an outer circumferential surface to an inner circumferential surface of the intermediate heat transfer pipe.

Advantageous Effects of Invention

[0007]

In the heat exchanger according to the present invention, the areas between the tops of the projections and the bottoms of the recesses of the intermediate heat transfer pipe are formed with the plurality of first openings passing through from the outer circumferential surface to the inner circumferential surface of the intermediate heat transfer pipe. Accordingly, the first heat medium is allowed to move back and forth between the intermediate heat transfer pipe outer flow path and the intermediate heat transfer pipe inner flow path. Thus, the flow rate of the first heat medium in the respective flow paths is made uniform, and the heat exchange efficiency is improved. Further, the stirring is facilitated, and the heat exchange efficiency is improved.

Brief Description of Drawings

[0008]
[Fig. 1] Fig. 1 is a sectional view of a heat exchanger according to Embodiment 1 of the present invention in a direction parallel to an axis of the heat exchanger.

[Fig. 2] Fig. 2 is a sectional view of the heat exchanger according to Embodiment 1 of the present invention in a direction perpendicular to the axis.

[Fig. 3] Fig. 3 is a perspective view of the heat exchanger according to Embodiment 1 of the present invention. Fig. 3 shows the heat exchanger in which an outer heat transfer pipe is removed.

[Fig. 4] Fig. 4 is a partial enlarged perspective view of a heat exchanger according to Embodiment 2 of the present invention. Fig. 4 shows the heat exchanger in which the outer heat transfer pipe is removed.

[Fig. 5] Fig. 5 is a sectional view of a louver of the heat exchanger according to Embodiment 2 of the present invention in a direction parallel to an axis of the heat exchanger.

[Fig. 6] Fig. 6 is a partial enlarged perspective view of a modified example of the heat exchanger according to Embodiment 2 of the present invention. Fig. 6 shows the heat exchanger in which the outer heat transfer pipe is removed.

[Fig. 7] Fig. 7 is a sectional view of a louver of the modified example of the heat exchanger according to Embodiment 2 of the present invention in a direction parallel to the axis.

[Fig. 8] Fig. 8 is a partial enlarged perspective view of a heat exchanger according to Embodiment 3 of the present invention. Fig. 8 shows the heat exchanger in which the outer heat transfer pipe is removed.

[Fig. 9] Fig. 9 is a sectional view of a slit of the heat exchanger according to Embodiment 3 of the present invention in a direction parallel to an axis of the heat exchanger.
[Fig. 10] Fig. 10 is a sectional view of a modified example of the heat exchanger according to Embodiment 3 of the present invention in a direction parallel to the axis.

[Fig. 11] Fig. 11 is a sectional view of a modified example of the heat exchanger according to Embodiment 3 of the present invention in a direction parallel to the axis.

[Fig. 12] Fig. 12 is a sectional view of a heat exchanger according to Embodiment 4 of the present invention in a direction parallel to an axis of the heat exchanger.

[Fig. 13] Fig. 13 is a sectional view of a heat exchanger according to Embodiment 5 of the present invention in a direction perpendicular to an axis of the heat exchanger.

[Fig. 14] Fig. 14 is a sectional view of a heat exchanger according to Embodiment 5 of the present invention in a direction perpendicular to the axis.

[Fig. 15] Fig. 15 is a diagram illustrating an example of the configuration of a refrigeration cycle apparatus according to Embodiment 6 of the present invention.

[Fig. 16] Fig. 16 is a diagram illustrating an example of the configuration of the refrigeration cycle apparatus according to Embodiment 6 of the present invention.

Description of Embodiments

[0009]

Heat exchangers according to the present invention will be described below with reference to the drawings.

In the following, a description will be given of a case in which heat exchangers according to the present invention are heat exchangers in which a first heat medium exchanges heat with a second heat medium flowing inside an
inner heat transfer pipe (so-called double-pipe heat exchangers). However, the present invention is not limited to such a case. Heat exchangers according to the present invention include, for example, a heat exchanger in which the first heat medium exchanges heat with the second heat medium flowing outside an outer heat transfer pipe and a heat exchanger in which the first heat medium exchanges heat with the second heat medium flowing inside the inner heat transfer pipe and a third heat medium flowing outside the outer heat transfer pipe (a so-called triple-pipe heat exchanger).

[0010]

Further, in the following, a description will be given of a case in which the first heat medium and the second heat medium are refrigerants flowing through a refrigerant circuit of a refrigeration cycle apparatus. However, the present invention is not limited to such a case. For example, the first heat medium or the second heat medium may be another fluid such as water. Further, the second heat medium may not flow inside or outside a pipe.

[0011]

Further, the configurations, operations, and other items described below are only exemplary, and the present invention is not limited to such configurations, operations, and other items. Further, in the drawings, the same or similar members or parts are designated by the same reference signs. Further, illustration of detailed structures is simplified or omitted as appropriate. Further, overlapping or similar descriptions will be simplified or omitted as appropriate.

[0012]

Embodiment 1

A heat exchanger according to Embodiment 1 will be described.

<Configuration of Heat Exchanger>
A configuration of the heat exchanger according to Embodiment 1 will be
described below.

Fig. 1 is a sectional view of the heat exchanger according to Embodiment
1 of the present invention in a direction parallel to an axis of the heat exchanger.

Fig. 2 is a sectional view of the heat exchanger according to Embodiment 1 of
the present invention in a direction perpendicular to the axis. As illustrated in
Fig. 1, a heat exchanger 1 includes an outer heat transfer pipe 11, an inner heat
transfer pipe 21, and an intermediate heat transfer pipe 31.

[0013]

An inner heat transfer pipe outer flow path 81 having a tubular shape is
formed between the outer heat transfer pipe 11 and the inner heat transfer pipe
21. An inner heat transfer pipe inner flow path 82 is formed inside the inner
heat transfer pipe 21. A first refrigerant flowing in through an inlet 12 of the
outer heat transfer pipe 11 flows out through an outlet 13 of the outer heat
transfer pipe 11. A second refrigerant flowing in through an inlet 22 of the inner
heat transfer pipe 21 flows out through an outlet 23 of the inner heat transfer pipe
21. The heat exchange efficiency is improved when the flow direction of the first
refrigerant and the flow direction of the second refrigerant are opposite to each
other. The flow direction of the first refrigerant and the flow direction of the
second refrigerant may be the same. The first refrigerant corresponds to a "first
heat medium" of the present invention. The second refrigerant corresponds to a
"second heat medium" of the present invention.

[0014]

The intermediate heat transfer pipe 31 is provided in a part of the inner
heat transfer pipe outer flow path 81 in the longitudinal direction thereof. An
intermediate heat transfer pipe outer flow path 83 is formed between an inner
circumferential surface of the outer heat transfer pipe 11 and an outer
circumferential surface of the intermediate heat transfer pipe 31. An intermediate heat transfer pipe inner flow path 84 is formed between an outer circumferential surface of the inner heat transfer pipe 21 and an inner circumferential surface of the intermediate heat transfer pipe 31. At an inlet 32 of the intermediate heat transfer pipe 31, the first refrigerant in the inner heat transfer pipe outer flow path 81 divides and flows into the intermediate heat transfer pipe outer flow path 83 and the intermediate heat transfer pipe inner flow path 84, and flows out through an outlet 33 of the intermediate heat transfer pipe 31.

The intermediate heat transfer pipe 31 has projections 34 and recesses 35 alternately formed in the circumferential direction of the inner heat transfer pipe outer flow path 81. Dividers 36 are interposed between tops of the projections 34 and bottoms of the recesses 35. The dividers 36 may be flat surfaces or bent surfaces bent toward the outside or inside of the intermediate heat transfer pipe 31. Although Fig. 2 illustrates a case in which the projections and the recesses are formed at angle intervals of 60 degrees, the present invention is not limited to such a case. Further, the angle intervals may not be equal.

At least a part of the tops of the projections 34 may be or may not be in contact with the inner circumferential surface of the outer heat transfer pipe 11. At least a part of the bottoms of the recesses 35 is in contact with the outer circumferential surface of the inner heat transfer pipe 21. The heat exchange efficiency is improved when the bottoms of the recesses 35 are in contact with the outer circumferential surface of the inner heat transfer pipe 21 over the entire area in the longitudinal direction of the intermediate heat transfer pipe 31 and in the entire direction around the axis. Further, the heat exchange efficiency is
further improved when the area of contact between the bottoms of the recesses 35 and the outer circumferential surface of the inner heat transfer pipe 21 is uniform in the entire direction around the axis.

[0017]

It is preferable to bring at least a part or all of the tops of the projections 34 into close contact with the inner circumferential surface of the outer heat transfer pipe 11 and bring at least a part or all of the bottoms of the recesses 35 into close contact with the outer circumferential surface of the inner heat transfer pipe 21 by inserting the inner heat transfer pipe 21 and the intermediate heat transfer pipe 31 in the outer heat transfer pipe 11 and thereafter compressing a part or all of the area of the outer heat transfer pipe 11 located outside the intermediate heat transfer pipe 31 in the entire direction around the axis or expanding a part or all of the area of the inner heat transfer pipe 21 located inside the intermediate heat transfer pipe 31 in the entire direction around the axis. When all of the area of the outer heat transfer pipe 11 located outside the intermediate heat transfer pipe 31 is compressed, or when all of the area of the inner heat transfer pipe 21 located inside the intermediate heat transfer pipe 31 is expanded, the contact is reliably made, and the heat exchange efficiency is further improved.

[0018]

Fig. 3 is a perspective view of the heat exchanger according to Embodiment 1 of the present invention. Fig. 3 shows the heat exchanger in which the outer heat transfer pipe is removed. As illustrated in Fig. 3, the dividers 36 of the intermediate heat transfer pipe 31 have a plurality of holes 41 formed in a zigzag manner along the longitudinal direction of the flow paths. The holes 41 are through holes passing through from the outer circumferential surface to the inner circumferential surface of the intermediate heat transfer pipe 31. The holes 41 are formed by pressing, for example. Although Fig. 3
illustrates a case in which the plurality of holes 41 is formed in the zigzag manner in a row in each of the dividers 36, the holes 41 may be formed in a plurality of rows. The holes 41 correspond to "first openings" of the present invention.

[0019]

<Functions of Heat Exchanger>

Functions of the heat exchanger according to Embodiment 1 will be described below.

In the heat exchanger 1, the plurality of holes 41 is formed in the dividers 36 of the intermediate heat transfer pipe 31. Therefore, the first refrigerant in the intermediate heat transfer pipe outer flow path 83 and the first refrigerant in the intermediate heat transfer pipe inner flow path 84 are allowed to move back and forth between each other through the holes 41. Thus, the flow rate of the first heat medium in the respective flow paths is made uniform, and the heat exchange efficiency is improved. Further, the stirring is facilitated, and the heat exchange efficiency is improved.

[0020]

Further, the plurality of holes 41 is formed in the zigzag manner in the heat exchanger 1. Therefore, the first refrigerant in the intermediate heat transfer pipe outer flow path 83 and the first refrigerant in the intermediate heat transfer pipe inner flow path 84 can be equally stirred, and the heat exchange efficiency is further improved.

[0021]

Embodiment 2

A heat exchanger according to Embodiment 2 will be described.

Descriptions overlapping or similar to those of Embodiment 1 will be simplified or omitted as appropriate.

<Configuration of Heat Exchanger>
A configuration of the heat exchanger according to Embodiment 2 will be described below.

Fig. 4 is a partial enlarged perspective view of the heat exchanger according to Embodiment 2 of the present invention. Fig. 4 shows the heat exchanger in which the outer heat transfer pipe is removed. As illustrated in Fig. 4, the dividers 36 of the intermediate heat transfer pipe 31 have a plurality of louvers 51 formed in a zigzag manner along the longitudinal direction of the flow paths.

[0022]

The louvers 51 are formed by cutting the dividers 36 of the intermediate heat transfer pipe 31 along bent cut lines 52 to pass through from the outer circumferential surface to the inner circumferential surface of the intermediate heat transfer pipe 31, that is, forming bent line-shaped cut surfaces 53 passing through from the outer circumferential surface to the inner circumferential surface of the intermediate heat transfer pipe 31, and bending respective areas inside the cut surfaces 53 toward the outside or inside of the intermediate heat transfer pipe 31 by pressing, for example. The cut surfaces 53 correspond to "first cut surfaces" of the present invention.

[0023]

It is preferable that a straight line connecting opposite ends 54 and 55 of each of the cut surfaces 53 crosses, particularly perpendicularly, the flow direction of the first refrigerant, and that the opposite ends 54 and 55 of each of the cut surfaces 53 are located downstream of a top 56 of each of the cut surfaces 53 in the flow direction of the first refrigerant, that is, the portion between the opposite ends of each of the cut surfaces 53 is bent upstream. It is also preferable that two adjacent ones of the louvers 51 are bent in mutually different directions of the intermediate heat transfer pipe 31. That is, one of the
louvers 51 adjacent to another of the louvers 51 being bent toward the outside of the intermediate heat transfer pipe 31 is bent toward the inside of the intermediate heat transfer pipe 31. The cut lines 52 may not be bent lines, and may be other curved lines, such as circular arcs each having a central angle exceeding 180 degrees and curved lines each formed by bending a straight line to form a vertex or vertices, for example.

Fig. 5 is a sectional view of a louver of the heat exchanger according to Embodiment 2 of the present invention in a direction parallel to an axis of the heat exchanger. Fig. 5 illustrates a case in which the louvers 51 project toward the outside of the intermediate heat transfer pipe 31. That is, in Fig. 5, the intermediate heat transfer pipe outer flow path 83 is on the upper side of the intermediate heat transfer pipe 31, and the intermediate heat transfer pipe inner flow path 84 is on the lower side of the intermediate heat transfer pipe 31. As illustrated in Fig. 5, the tops 56 of the cut surfaces 53 of the intermediate heat transfer pipe 31 project toward the outside of the outer circumferential surface of the intermediate heat transfer pipe 31 to form gaps 57. When the louvers 51 project toward the inside of the intermediate heat transfer pipe 31, the tops 56 of the cut surfaces 53 of the intermediate heat transfer pipe 31 similarly project toward the inside of the inner circumferential surface of the intermediate heat transfer pipe 31 to form the gaps 57. The gaps 57 correspond to the "first openings" of the present invention.

Functions of the heat exchanger according to Embodiment 2 will be described below.
In the heat exchanger 1, the tops 56 of the cut surfaces 53 of the louvers 51 project from the dividers 36. Therefore, the first refrigerant flowing through the intermediate heat transfer pipe outer flow path 83 and the first refrigerant flowing through the intermediate heat transfer pipe inner flow path 84 are guided by the louvers 51 to move back and forth between each other. Thus, the stirring is further facilitated, and the heat exchange efficiency is further improved.

[0026]

Further, in the heat exchanger 1, the tops 56 of the cut surfaces 53 of the louvers 51 project upstream in the flow direction of the first refrigerant. Therefore, the heat transfer between the intermediate heat transfer pipe 31 and the first refrigerant is facilitated by the leading edge effect caused by the hit of the first refrigerant against the tops 56 of the cut surfaces 53, and the heat exchange efficiency is further improved.

[0027]

Further, in the heat exchanger 1, two adjacent ones of the louvers 51 are bent in the mutually different directions of the intermediate heat transfer pipe 31. Therefore, both the refrigerant flowing through the intermediate heat transfer pipe outer flow path 83 and the first refrigerant flowing through the intermediate heat transfer pipe inner flow path 84 can be equally stirred, and the heat exchange efficiency is further improved.

[0028]

<Modified Example>

Fig. 6 is a partial enlarged perspective view of a modified example of the heat exchanger according to Embodiment 2 of the present invention. Fig. 6 shows the heat exchanger in which the outer heat transfer pipe is removed. Although the cut lines 52 of the louvers 51 have shown to be curved lines in the heat exchanger 1, the cut lines 52 of the louvers 51 may be straight lines, as
illustrated in Fig. 6. The louvers 51 are formed by pressing, for example, to extrude areas of the intermediate heat transfer pipe 31 located downstream of the cut surfaces 53 toward the outside or inside of the intermediate heat transfer pipe 31.

Fig. 7 is a sectional view of a louver of the modified example of the heat exchanger according to Embodiment 2 of the present invention in a direction parallel to the axis. Fig. 7 illustrates a case in which the louvers 51 project toward the outside of the intermediate heat transfer pipe 31. As illustrated in Fig. 7, portions of the inner circumferential surface of the intermediate heat transfer pipe 31 located downstream of the cut surfaces 53 project toward the outside of the outer circumferential surface of the intermediate heat transfer pipe 31 to form the gaps 57. When the louvers 51 project toward the inside of the intermediate heat transfer pipe 31, portions of the outer circumferential surface of the intermediate heat transfer pipe 31 located downstream of the cut surfaces 53 similarly project toward the inside of the inner circumferential surface of the intermediate heat transfer pipe 31 to form the gaps 57. Also in such cases, the heat transfer between the intermediate heat transfer pipe 31 and the first refrigerant is facilitated by the leading edge effect caused by the hit of the first refrigerant against the cut surfaces 53, and the heat exchange efficiency is improved.

Embodiment 3

A heat exchanger according to Embodiment 3 will be described.

Descriptions overlapping or similar to those of Embodiment 1 and Embodiment 2 will be simplified or omitted as appropriate.

<Configuration of Heat Exchanger>
A configuration of the heat exchanger according to Embodiment 3 will be described below.

Fig. 8 is a partial enlarged perspective view of the heat exchanger according to Embodiment 3 of the present invention. Fig. 8 shows the heat exchanger in which the outer heat transfer pipe is removed. As illustrated in Fig. 8, the dividers 36 of the intermediate heat transfer pipe 31 have a plurality of slits 61 formed in a zigzag manner along the longitudinal direction of the flow paths.

[0031]

The slits 61 are formed by cutting the dividers 36 of the intermediate heat transfer pipe 31 along straight line-shaped upstream side cut lines 62 and straight line-shaped downstream side cut lines 63 to pass through from the outer circumferential surface to the inner circumferential surface of the intermediate heat transfer pipe 31, that is, forming straight line-shaped upstream side cut surfaces 64 and straight line-shaped downstream side cut surfaces 65 passing through from the outer circumferential surface to the inner circumferential surface of the intermediate heat transfer pipe 31, and by pressing, for example, to extrude the area between each of the upstream side cut surfaces 64 and the corresponding one of the downstream side cut surfaces 65 toward the outside or inside of the intermediate heat transfer pipe 31. The upstream side cut surfaces 64 and the downstream side cut surfaces 65 are preferably formed to be alongside each other along the flow direction of the first refrigerant. The upstream side cut surfaces 64 correspond to the "first cut surfaces" of the present invention. The downstream side cut surfaces 65 correspond to "second cut surfaces" of the present invention.

[0032]
It is preferable that a straight line connecting opposite ends 66 and 67 of each of the upstream side cut surfaces 64 and a straight line connecting opposite ends 68 and 69 of each of the downstream side cut surfaces 65 cross, particularly perpendicularly, the flow direction of the first refrigerant. It is preferable to extrude two adjacent ones of the slits 61 in mutually different directions of the intermediate heat transfer pipe 31. That is, one of the slits 61 adjacent to another of the slits 61 being extruded toward the outside of the intermediate heat transfer pipe 31 is extruded toward the inside of the intermediate heat transfer pipe 31.

The upstream side cut lines 62 and the downstream side cut lines 63 may not be straight lines, and may be curved lines, such as bent lines, for example. In such a case, it is preferable that the portion between the opposite ends 66 and 67 of each of the upstream side cut surfaces 64 is bent upstream, and that the portion between the opposite ends 68 and 69 of each of the downstream side cut surfaces 65 is bent downstream.

Fig. 9 is a sectional view of a slit of the heat exchanger according to Embodiment 3 of the present invention. Fig. 9 illustrates a case in which the slits 61 project toward the outside of the intermediate heat transfer pipe 31. As illustrated in Fig. 9, a portion of the inner circumferential surface of the intermediate heat transfer pipe 31 between each of the upstream side cut surfaces 64 and the corresponding one of the downstream side cut surfaces 65 projects toward the outside of the outer circumferential surface of the intermediate heat transfer pipe 31 to form upstream side gaps 70 and downstream side gaps 71. When the slits 61 project toward the inside of the intermediate heat transfer pipe 31, a portion of the outer circumferential surface
of the intermediate heat transfer pipe 31 between each of the upstream side cut surfaces 64 and the corresponding one of the downstream side cut surfaces 65 similarly projects toward the inside of the inner circumferential surface of the intermediate heat transfer pipe 31 to form the upstream side gaps 70 and the downstream side gaps 71. The upstream side gaps 70 correspond to the "first openings" of the present invention. The downstream side gaps 71 correspond to "second openings" of the present invention.

[0035]

<Functions of Heat Exchanger>

Functions of the heat exchanger according to Embodiment 3 will be described below.

In the heat exchanger 1, the downstream side gaps 71 are formed in addition to the upstream side gaps 70. Therefore, even when the first refrigerant is caused to flow backward, the first refrigerant flowing through the intermediate heat transfer pipe outer flow path 83 and the first refrigerant flowing through the intermediate heat transfer pipe inner flow path 84 are guided by the slits 61 to move back and forth between each other. Thus, the stirring is facilitated, and the heat exchange efficiency is further improved. The refrigerant caused to flow backward may be a heat medium different from the first refrigerant.

[0036]

Further, in the heat exchanger 1, even when the first refrigerant is caused to flow backward, the heat transfer between the intermediate heat transfer pipe 31 and the first refrigerant is facilitated by the leading edge effect caused by the hit of the first refrigerant against the downstream side cut surfaces 65, and the heat exchange efficiency is improved.

[0037]
Further, in the heat exchanger 1, two adjacent ones of the slits 61 are extruded in the mutually different directions of the intermediate heat transfer pipe 31. Therefore, both the refrigerant flowing through the intermediate heat transfer pipe outer flow path 83 and the first refrigerant flowing through the intermediate heat transfer pipe inner flow path 84 can be equally stirred, and the heat exchange efficiency is further improved.

[0038]

Further, in the heat exchanger 1, the upstream side gaps 70 and the downstream side gaps 71 are formed by simple processing of extruding the areas of the intermediate heat transfer pipe 31 between the upstream side cut surfaces 64 and the corresponding downstream side cut surfaces 65 in one direction. Accordingly, an increase in manufacturing processes or the like is suppressed.

[0039]

<Modified Examples>

Fig. 10 is a sectional view of a modified example of the heat exchanger according to Embodiment 3 of the present invention in a direction parallel to an axis of the heat exchanger. Fig. 10 illustrates a case in which the upstream side cut surfaces 64 project toward the outside of the intermediate heat transfer pipe 31, and the downstream side cut surfaces 65 project toward the inside of the intermediate heat transfer pipe 31. As illustrated in Fig. 10, in each of the slits 61, an area of the intermediate heat transfer pipe 31 located downstream of each of the upstream side cut surfaces 64 and an area of the intermediate heat transfer pipe 31 located upstream of each of the downstream side cut surfaces 65 may be extruded toward different sides of the intermediate heat transfer pipe 31 such that a portion of the inner circumferential surface of the intermediate heat transfer pipe 31 located downstream of each of the upstream side cut
surfaces 64 projects toward the outside of the outer circumferential surface of the intermediate heat transfer pipe 31, and that a portion of the outer circumferential surface of the intermediate heat transfer pipe 31 located upstream of each of the downstream side cut surfaces 65 projects toward the inside of the inner circumferential surface of the intermediate heat transfer pipe 31.

[0040]

Fig. 11 is a sectional view of a modified example of the heat exchanger according to Embodiment 3 of the present invention in a direction parallel to the axis. Fig. 11 illustrates a case in which the downstream side of each of the upstream side cut surfaces 64 projects toward the outside of the intermediate heat transfer pipe 31, and the upstream side of each of the upstream side cut surfaces 64 projects toward the inside of the intermediate heat transfer pipe 31. As illustrated in Fig. 11, each of the slits 61 may not be formed with the downstream side cut surfaces 65 and may be formed only with each of the upstream side cut surfaces 64, with an area of the intermediate heat transfer pipe 31 located downstream of each of the upstream side cut surfaces 64 and an area of the intermediate heat transfer pipe 31 located upstream of each of the upstream side cut surfaces 64 extruded toward different sides of the intermediate heat transfer pipe 31 such that a portion of the inner circumferential surface of the intermediate heat transfer pipe 31 located downstream of each of the upstream side cut surfaces 64 projects toward the outside of the outer circumferential surface of the intermediate heat transfer pipe 31, and that a portion of the outer circumferential surface of the intermediate heat transfer pipe 31 located upstream of each of the upstream side cut surfaces 64 projects toward the inside of the inner circumferential surface of the intermediate heat transfer pipe 31.

[0041]
In a case such as that in Fig. 11, the portion of the inner circumferential surface of the intermediate heat transfer pipe 31 located downstream of each of the upstream side cut surfaces 64 and the portion of the outer circumferential surface of the intermediate heat transfer pipe 31 located upstream of each of the upstream side cut surfaces 64 are not necessarily required to project from the outer circumferential surface and the inner circumferential surface of the intermediate heat transfer pipe 31, respectively, as long as gaps 72 are formed. The gaps 72 correspond to the “first openings” of the present invention.

[0042]

Embodiment 4

A heat exchanger according to Embodiment 4 will be described.

Descriptions overlapping or similar to those of Embodiment 1 to Embodiment 3 will be simplified or omitted as appropriate.

<Configuration of Heat Exchanger>

A configuration of the heat exchanger according to Embodiment 4 will be described below.

Fig. 12 is a sectional view of the heat exchanger according to Embodiment 4 of the present invention in a direction parallel to an axis of the heat exchanger. As illustrated in Fig. 12, the intermediate heat transfer pipe 31 is formed of an upstream side area 37 and a downstream side area 38. The upstream side area 37 is formed with the plurality of louvers 51 or the plurality of slits 61. The downstream side area 38 is not formed with the louvers 51 or the slits 61. In the downstream side area 38, the plurality of holes 41 may or may not be formed, and the outer circumferential surface and the inner circumferential surface of the intermediate heat transfer pipe 31 may preferably be smooth.

[0043]

<Functions of Heat Exchanger>
Functions of the heat exchanger according to Embodiment 4 will be described below.

In the heat exchanger 1, the louvers 51 or the slits 61 projecting from the outer circumferential surface or the inner circumferential surface of the intermediate heat transfer pipe 31 are formed only in the upstream side area 37 of the intermediate heat transfer pipe 31. In the upstream side area 37, therefore, the louvers 51 or the slits 61 disturb the flow of the first refrigerant, thereby efficiently facilitating the stirring. Further, since the louvers 51 or the slits 61 are not formed in the downstream side area 38, an increase in pressure loss is suppressed.

[0044]

Embodiment 5

A heat exchanger according to Embodiment 5 will be described.

Descriptions overlapping or similar to those of Embodiment 1 to Embodiment 4 will be simplified or omitted as appropriate.

<Configuration of Heat Exchanger>

A configuration of the heat exchanger according to Embodiment 5 will be described below.

Fig. 13 and Fig. 14 are sectional views of the heat exchanger according to Embodiment 5 of the present invention in a direction perpendicular to an axis of the heat exchanger. As illustrated in Fig. 13 and Fig. 14, the dividers 36 are bent toward the outside or inside of the intermediate heat transfer pipe 31. The dividers 36 have the plurality of louvers 51 or the plurality of slits 61 formed to project from the outer circumferential surface or the inner circumferential surface of the intermediate heat transfer pipe 31 toward a side different from the side toward which the dividers 36 are bent.

[0045]
That is, when the dividers 36 are bent toward the outside of the intermediate heat transfer pipe 31, as illustrated in Fig. 13, the plurality of louvers 51 or the plurality of slits 61 is formed such that the portion of the outer circumferential surface of the intermediate heat transfer pipe 31 located downstream of each of the cut surfaces 53 or located in the area between each of the upstream side cut surfaces 64 and the corresponding one of downstream side cut surfaces 65 projects toward the inside from the inner circumferential surface of the intermediate heat transfer pipe 31. Further, if the dividers 36 are bent toward the inside of the intermediate heat transfer pipe 31, as illustrated in Fig. 14, the plurality of louvers 51 or the plurality of slits 61 is formed such that the portion of the inner circumferential surface of the intermediate heat transfer pipe 31 located downstream of each of the cut surfaces 53 or located in the area between each of the upstream side cut surfaces 64 and the corresponding one of downstream side cut surfaces 65 projects toward the outside from the outer circumferential surface of the intermediate heat transfer pipe 31.

<Functions of Heat Exchanger>

Functions of the heat exchanger according to Embodiment 5 will be described below.

If the dividers 36 are bent toward the outside or inside of the intermediate heat transfer pipe 31, force for increasing the curvature of the bend acts when a part or all of the area of the outer heat transfer pipe 11 located outside the intermediate heat transfer pipe 31 is compressed in the entire direction around the axis or a part or all of the area of the inner heat transfer pipe 21 located inside the intermediate heat transfer pipe 31 is expanded in the entire direction around the axis after the inner heat transfer pipe 21 and the intermediate heat transfer pipe 31 are inserted in the outer heat transfer pipe 11. That is,
compressive force acts on the inside of the bend, and tensile force acts on the outside of the bend.

[0047]

In such a case, when the louvers 51 or the plurality of slits 61 is formed to project from the outer circumferential surface or the inner circumferential surface of the intermediate heat transfer pipe 31 toward the same side as the side toward which the dividers 36 are bent, tensile force acts between the opposite ends 54 and 55 of each of the cut surfaces 53 or between the opposite ends 66 and 67 of each of the upstream side cut surfaces 64 and between the opposite ends 68 and 69 of each of the downstream side cut surfaces 65, thereby reducing the projection amount (height of projection) thereof.

[0048]

Since the louvers 51 or the plurality of slits 61 in the heat exchanger 1 is formed to project from the outer circumferential surface or the inner circumferential surface of the intermediate heat transfer pipe 31 toward the side different from the side toward which the dividers 36 are bent, compressive force acts between the opposite ends 54 and 55 of each of the cut surfaces 53 or between the opposite ends 66 and 67 of each of the upstream side cut surfaces 64 and between the opposite ends 68 and 69 of each of the downstream side cut surfaces 65, with no reduction in the projection amount thereof. Accordingly, the stirring is reliably facilitated.

[0049]

<Modified Example>

The dividers 36 may be formed with the louvers 51 or the slits 61 projecting from the outer circumferential surface or the inner circumferential surface of the intermediate heat transfer pipe 31 toward the same side as the side toward which the dividers 36 are bent, in addition to the louvers 51 or the
slits 61 projecting from the outer circumferential surface or the inner circumferential surface of the intermediate heat transfer pipe 31 toward the side different from the side toward which the dividers 36 are bent. In such a case, the length of the cut lines, for example, may preferably be set such that the projection amount of the louvers 51 or the slits 61 projecting toward the side different from the side of bend is smaller than the projection amount of the louvers 51 or the slits 61 projecting toward the same side as the side toward which the dividers 36 are bent in a state before the expansion or compression of the intermediate heat transfer pipe 31.

Embodiment 6

A refrigeration cycle apparatus according to Embodiment 6 will be described.

The following is only a description of an example of application of the heat exchanger 1 according to Embodiment 1 to Embodiment 5, and the present invention is not limited to a case in which the heat exchanger 1 according to Embodiment 1 to Embodiment 5 is applied to the refrigeration cycle apparatus as described below.

<Configuration of Refrigeration Cycle Apparatus>

A configuration of the refrigeration cycle apparatus according to Embodiment 6 will be described below.

Fig. 15 is a diagram illustrating an example of the configuration of the refrigeration cycle apparatus according to Embodiment 6 of the present invention. As illustrated in Fig. 15, a refrigeration cycle apparatus 91 includes a refrigerant circuit in which a compressor 92, a first heat exchanger 93, a second heat exchanger 94, an expansion device 95, and a third heat exchanger 96 are connected by pipes.
A high-pressure gaseous refrigerant compressed by the compressor 92 flows into the first heat exchanger 93. In the first heat exchanger 93, the high-pressure gaseous refrigerant exchanges heat with a heat medium supplied to the first heat exchanger 93, and thereby condenses into a liquid-phase refrigerant. The liquid-phase refrigerant is subcooled in the second heat exchanger 94 by a low-temperature gaseous refrigerant flowing from the third heat exchanger 96. Thereafter, the liquid-phase refrigerant flows into the expansion device 95 to be reduced in pressure to become a low-pressure two-phase gas-liquid refrigerant, and flows into the third heat exchanger 96. The two-phase gas-liquid refrigerant exchanges heat with a heat medium supplied to the third heat exchanger 96, and thereby evaporates into a gaseous refrigerant. The gaseous refrigerant is superheated in the second heat exchanger 94 by a high-temperature liquid-phase refrigerant flowing from the first heat exchanger 93, and thereafter flows again into the compressor 92.

The first heat exchanger 93 may be the heat source side, and the third heat exchanger 96 may be the load side. Further, the first heat exchanger 93 may be the load side, and the third heat exchanger 96 may be the heat source side. The heat exchanger 1 is used in at least one of the first heat exchanger 93, the second heat exchanger 94, and the third heat exchanger 96. The refrigerant supplied to the inner heat transfer pipe outer flow path 81 of the heat exchanger 1 corresponds to the "first heat medium" of the present invention, and the refrigerant supplied to the inner heat transfer pipe inner flow path 82 of the heat exchanger 1 corresponds to the "second heat medium" of the present invention.
When the heat exchanger 1 is used in the second heat exchanger 94, the high-temperature liquid-phase refrigerant flowing from the first heat exchanger 93 may be supplied to the inner heat transfer pipe outer flow path 81, and the low-temperature gaseous refrigerant flowing from the third heat exchanger 96 may be supplied to the inner heat transfer pipe inner flow path 82. Further, the high-temperature liquid-phase refrigerant flowing from the first heat exchanger 93 may be supplied to the inner heat transfer pipe inner flow path 82, and the low-temperature gaseous refrigerant flowing from the third heat exchanger 96 may be supplied to the inner heat transfer pipe outer flow path 81.

Fig. 16 is a diagram illustrating an example of the configuration of the refrigeration cycle apparatus according to Embodiment 6 of the present invention. As illustrated in Fig. 16, the refrigeration cycle apparatus 91 may further include a flow switching device (a four-way valve, for example) 97 on the discharge side of the compressor 92 and may be able to reverse the circulation direction of the refrigerant.

When the heat exchanger 1 according to Embodiment 3 is used in the second heat exchanger 94, the high-temperature liquid-phase refrigerant flowing from the first heat exchanger 93 may be supplied to the inner heat transfer pipe outer flow path 81. In the inner heat transfer pipe outer flow path 81 of the heat exchanger 1 according to Embodiment 3, the stirring continues to be facilitated, even when the flow direction in the inner heat transfer pipe outer flow path 81 is reversed, owing to the formation of the slits 61. Therefore, instead of the low-temperature gaseous refrigerant flowing from the third heat exchanger 96 and having a flow direction that is not reversed in accordance with the switching of the flow switching device 97, the high-temperature liquid-phase refrigerant
flowing from the first heat exchanger 93 and having a flow direction that is reversed in accordance with the switching of the flow switching device 97 is preferably supplied to the inner heat transfer pipe outer flow path 81.

[0056]

<Functions of Refrigeration Cycle Apparatus>

Functions of the refrigeration cycle apparatus according to Embodiment 6 will be described below.

With the heat exchanger 1 according to one of Embodiment 1 to Embodiment 5 used in a heat exchanger of the refrigerant circuit, the refrigeration cycle apparatus 91 is improved in heat exchange efficiency and thus improved in environmental performance such as energy saving performance, and is also reduced in size.

[0057]

Although the foregoing description has been given of Embodiment 1 to Embodiment 6, the present invention is not limited to the description of Embodiment 1 to Embodiment 6. For example, each of Embodiment 1 to Embodiment 6 and each of the modified examples can be combined.

Reference Signs List

[0058]

1 heat exchanger 11 outer heat transfer pipe 12 inlet 13 outlet 21 inner heat transfer pipe 22 inlet 23 outlet 31 intermediate heat transfer pipe 32 inlet 33 outlet 34 projection 35 recess 36 divider 37 upstream side area 38 downstream side area 41 hole 51 louver 52 cut line 53 cut surface 54, 55 opposite ends of cut surface 56 top of cut surface 57 gap 61 slit 62 upstream side cut line 63 downstream side cut line 64 upstream side cut surface 65
downstream side cut surface  66, 67  opposite ends of upstream side cut surface  68, 69  opposite ends of downstream side cut surface  70  upstream side gap  71  downstream side gap  72  gap  81 inner heat transfer pipe outer flow path  82  inner heat transfer pipe inner flow path  83  intermediate heat transfer pipe outer flow path  84 intermediate heat transfer pipe inner flow path  91  refrigeration cycle apparatus  92  compressor  93  first heat exchanger  94 second heat exchanger  95  expansion device  96  third heat exchanger  97  flow switching device
CLAIMS

[Claim 1]

A heat exchanger in which an inner circumferential surface of an outer heat transfer pipe and an outer circumferential surface of an inner heat transfer pipe form a tubular flow path, and a first heat medium flowing through the flow path and a second heat medium outside the outer heat transfer pipe or inside the inner heat transfer pipe exchange heat,

wherein the tubular flow path is provided with an intermediate heat transfer pipe having projections and recesses alternately formed in a circumferential direction of the flow path,

wherein at least a part of tops of the projections or at least a part of bottoms of the recesses of the intermediate heat transfer pipe is in contact with one of the outer heat transfer pipe and the inner heat transfer pipe being in contact with the second heat medium, and

wherein areas of the intermediate heat transfer pipe between the tops and the bottoms are formed with a plurality of first openings passing through from an outer circumferential surface to an inner circumferential surface of the intermediate heat transfer pipe.

[Claim 2]

The heat exchanger of claim 1, wherein the areas of the intermediate heat transfer pipe between the tops and the bottoms are formed with linear first cut surfaces passing through from the outer circumferential surface to the inner circumferential surface of the intermediate heat transfer pipe,

wherein a straight line connecting opposite ends of each of the first cut surfaces crosses a longitudinal direction of the flow path, and

wherein each of portions of the inner circumferential surface of the intermediate heat transfer pipe located downstream of corresponding one of the
first cut surfaces projects toward an outside of the outer circumferential surface
of the intermediate heat transfer pipe, or each of portions of the outer
circumferential surface of the intermediate heat transfer pipe located downstream
of corresponding one of the first cut surfaces projects toward an inside of the
inner circumferential surface of the intermediate heat transfer pipe, to thereby
form the first openings.

[Claim 3]

The heat exchanger of claim 2, wherein a portion between the opposite
ends of each of the first cut surfaces projects upstream.

[Claim 4]

The heat exchanger of claim 2 or 3, wherein the areas of the intermediate
heat transfer pipe between the tops and the bottoms are formed with linear
second cut surfaces passing through from the outer circumferential surface to the
inner circumferential surface of the intermediate heat transfer pipe,

wherein a straight line connecting opposite ends of each of the second cut
surfaces crosses the longitudinal direction of the flow path, and

wherein each of portions of the inner circumferential surface of the
intermediate heat transfer pipe located upstream of corresponding one of the
second cut surfaces projects toward the outside of the outer circumferential
surface of the intermediate heat transfer pipe, or each of portions of the outer
circumferential surface of the intermediate heat transfer pipe located upstream of
corresponding one of the second cut surfaces projects toward the inside of the
inner circumferential surface of the intermediate heat transfer pipe, to thereby
form second openings.

[Claim 5]
The heat exchanger of claim 4, wherein each of the second cut surfaces is formed alongside and downstream of corresponding one of the first cut surfaces, and

wherein each of areas of the inner circumferential surface of the intermediate heat transfer pipe between corresponding one of the first cut surfaces and corresponding one of the second cut surfaces projects from the outer circumferential surface of the intermediate heat transfer pipe, or each of areas of the outer circumferential surface of the intermediate heat transfer pipe between corresponding one of the first cut surfaces and corresponding one of the second cut surfaces projects from the inner circumferential surface of the intermediate heat transfer pipe, to thereby form the first openings and the second openings.

[Claim 6]

The heat exchanger of any one of claims 2 to 5, wherein, in two adjacent ones of the plurality of first openings, a portion of the inner circumferential surface and a portion of the outer circumferential surface of the intermediate heat transfer pipe located downstream of the first cut surfaces project toward mutually different sides from the outer circumferential surface or the inner circumferential surface of the intermediate heat transfer pipe.

[Claim 7]

The heat exchanger of any one of claims 2 to 5, wherein the areas of the intermediate heat transfer pipe between the tops and the bottoms are bent toward the inside or outside of the intermediate heat transfer pipe, and

wherein each of the portions of the inner circumferential surface or the outer circumferential surface of the intermediate heat transfer pipe located downstream of the corresponding one of the first cut surfaces projects from the
outer circumferential surface or the inner circumferential surface of the
intermediate heat transfer pipe toward a side different from the side of the bend.

[Claim 8]

The heat exchanger of any one of claims 2 to 7, wherein the intermediate
heat transfer pipe is formed of an upstream side area and a downstream side
area that divide the flow path in the longitudinal direction into two parts, and
wherein the first openings are formed only in the upstream side area.

[Claim 9]

The heat exchanger of any one of claims 1 to 8, wherein the plurality of
first openings in the intermediate heat transfer pipe is provided in a zigzag
manner along a longitudinal direction of the flow path.

[Claim 10]

A refrigeration cycle apparatus using the heat exchanger of any one of
claims 1 to 9.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

F28D7/10 (2006.01)i, F28F1/40 (2006.01)i, F28F13/08 (2006.01)i, F28F13/12 (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)

F28D7/10, F28F1/40, F28F13/08, F28F13/12

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
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<td>JP 2012-63067 A (Miura Co., Ltd.), 29 March 2012 (29.03.2012), entire text; all drawings (particularly, paragraphs [0057] to [0061]; fig. 6, 7) (Family: none)</td>
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Date of the actual completion of the international search 08 May, 2013 (08.05.13)

Date of mailing of the international search report 21 May, 2013 (21.05.13)

Name and mailing address of the ISA/Authorized officer

Facsimile No. Telephone No.
### INTERNATIONAL SEARCH REPORT

**DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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